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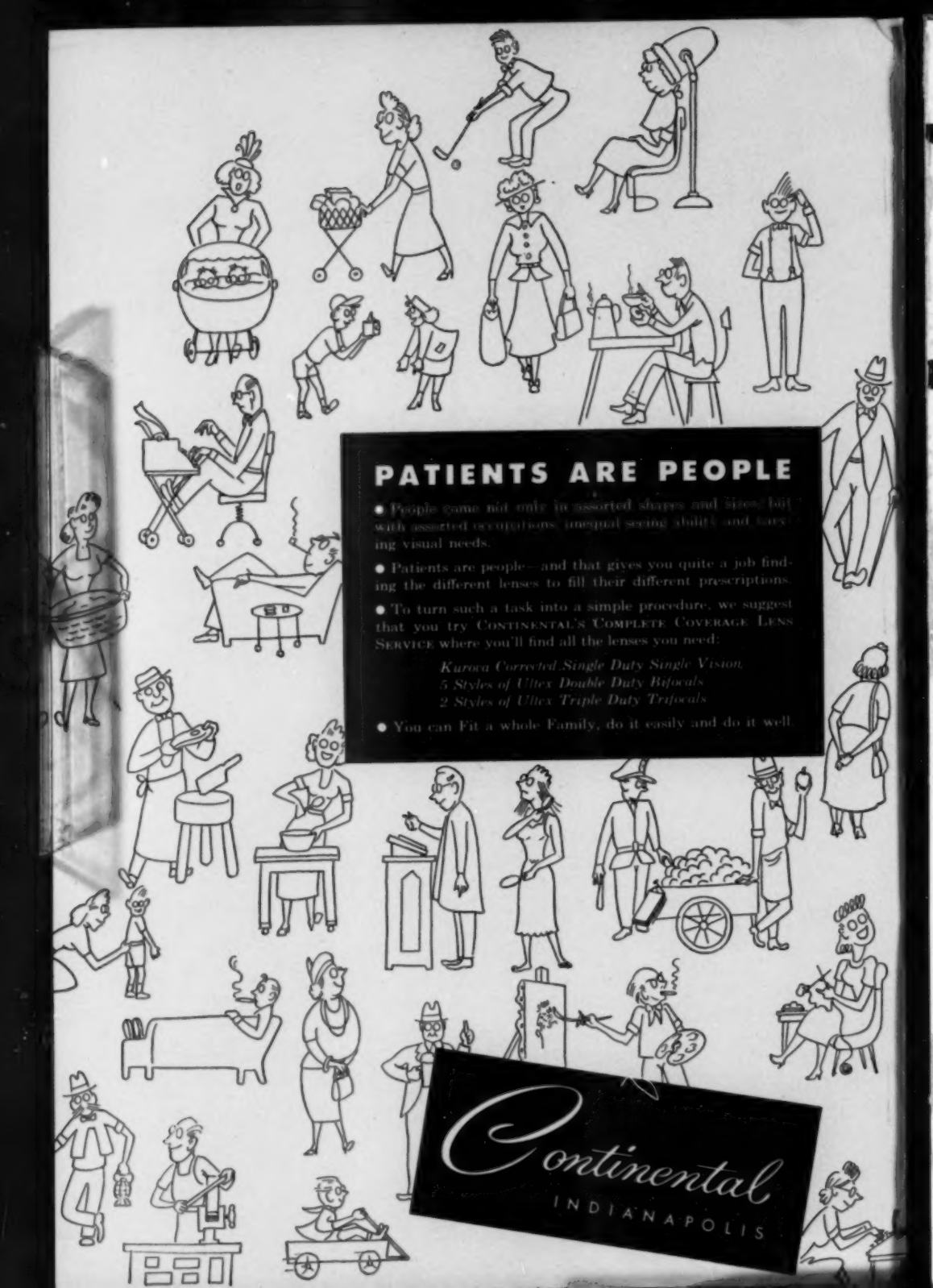
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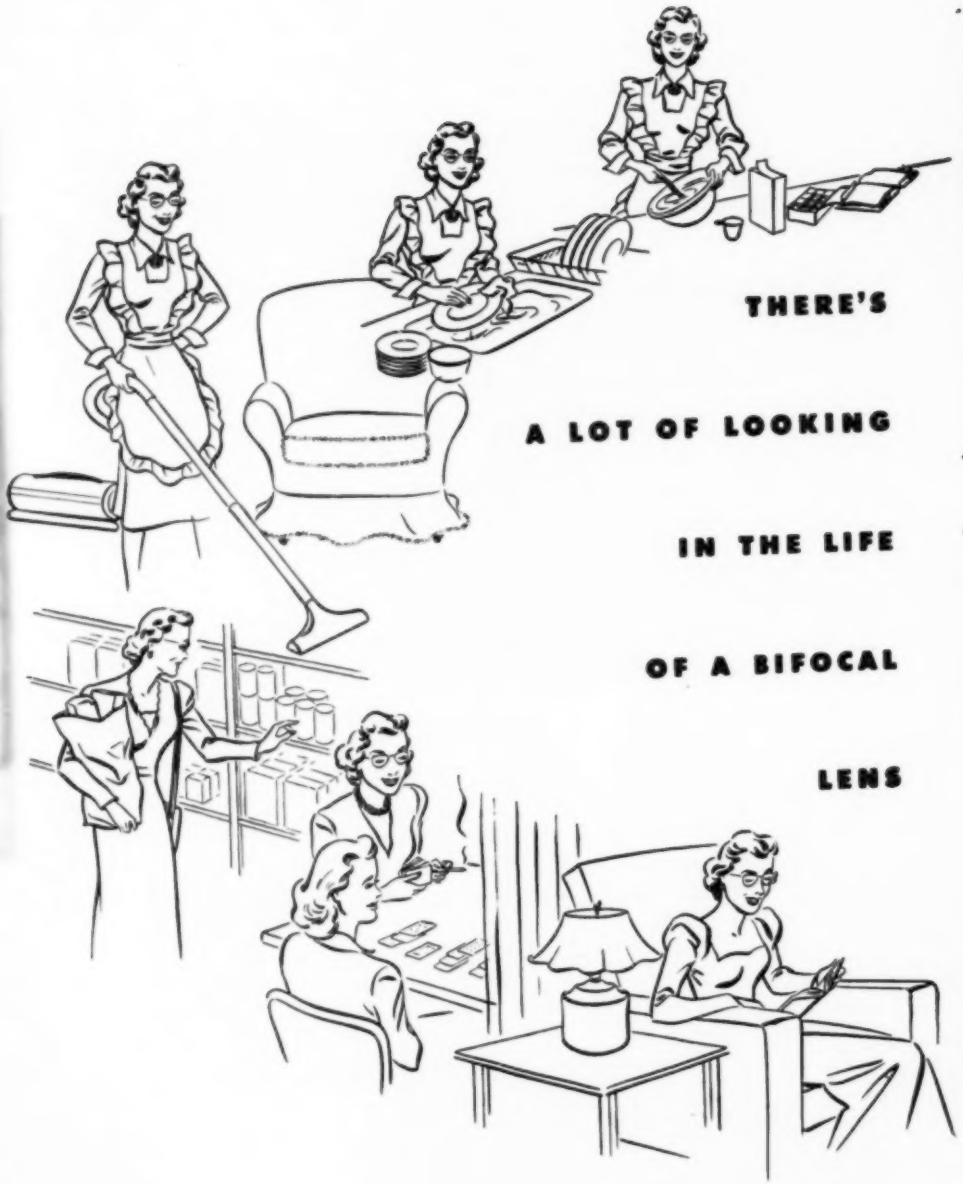

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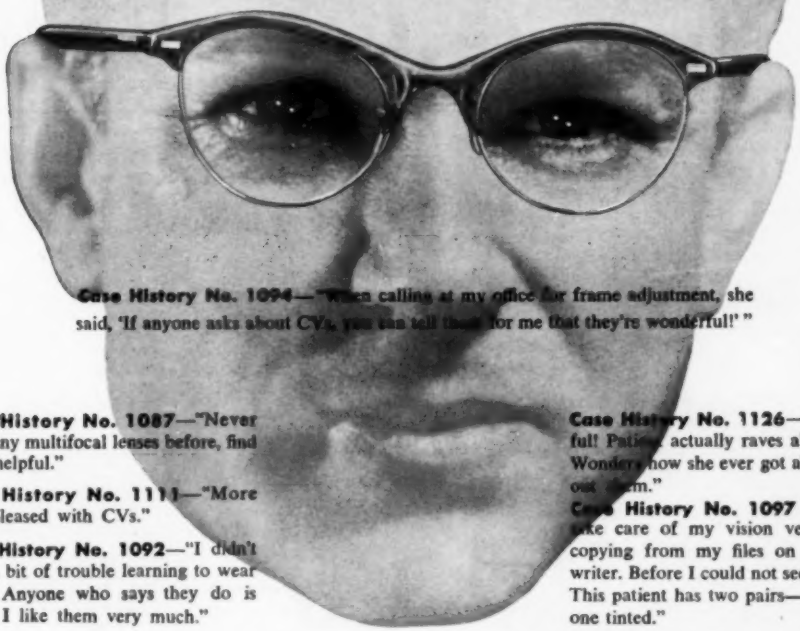

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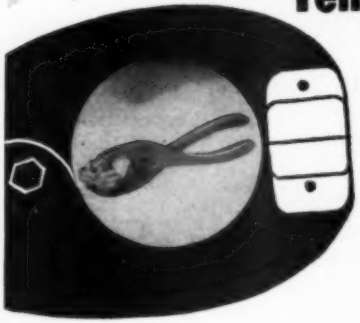

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Solve Stenstrom, M.D.

Translated from the original German by

Daniel Woolf, O.D.

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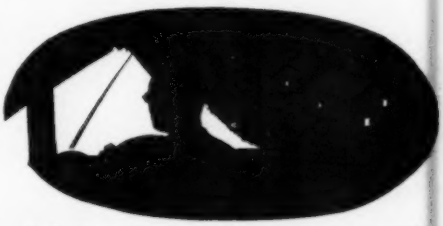

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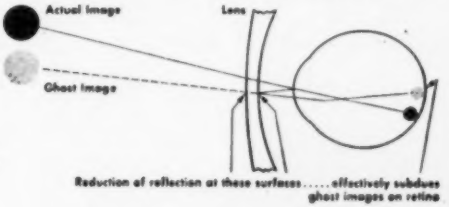

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Vol. 29 July, 1952 No. 7

SUGGESTIONS FOR A NEW FEE STRUCTURE IN OPTOMETRY*

Carel C. Koch†
Minneapolis, Minnesota

PART I‡

INTRODUCTION

The total cost of visual care to the patient has been closely linked with the cost of ophthalmic materials, and the fee charged the patient for these materials by the optometrist. This condition has prevailed since glasses were first produced in quantity for the consuming public. During the last 20 years various proposals have been made to separate the charges made for materials from the essentially professional service fees. Notable among these proposals were those of the American Optical Company and the two slightly different proposals of the American Optometric Association which were given considerable study by optometrists during this period.

In each of the proposals, various services performed by optometrists were given appropriate portions of the total fee, these being broken down by the skill required and time consumed in performing the service. The cost of materials was added and the total overall amount became the single professional bill submitted to the patient.

While these plans gave the optometrist a rather clear picture of his fees and where his total remuneration came from, they generally resulted in the patient's receiving one overall statement for the total services rendered. Each plan was complex and, while rather easily understood by the optometrist, patients were either confused or unaware of how the total was arrived at, and generally left the optometrist's office remembering only that "their glasses cost such-and-such a figure."

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*Presented before the annual meeting of the North Dakota Optometric Association, Fargo, North Dakota, May 24, 1952. For publication in the July, 1952, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist, Editor, American Journal of Optometry and Archives of American Academy of Optometry, Fellow, American Academy of Optometry, Secretary, American Academy of Optometry.

‡Part II of this report will appear in the August issue.

This total overall amount was not, in any sense, an overcharge for the work done. The total fee for services and materials dispensed was modest as a rule, and nation wide surveys indicate that during the last dozen years or so, in spite of the inflationary cycle, these total charges increased only about 30 per cent, while most everything else increased from 60 per cent to 110 per cent.

On the other hand, patients generally believed that their glasses were high priced. In paying only one overall fee, as most did who were served by optometrists, they had slowly drifted into an almost universal belief that the cost of visual care was outrageously high, and patients seemed to receive some sort of malicious satisfaction in telling about paying high prices for their glasses. Most, of course, paid average modest bills, but the general belief was that "glasses were subject to a very high markup at the hands of optometrists."

The contributing causes to this rather general belief have been several. The first is the optometric price advertiser who advertises complete glasses for some very low amount. The fact that he rarely supplies them at this price is ignored by the public when discussing this subject.

The second is the Federal government's attack upon those laboratories and ophthalmologists who were involved in the so-called "kick-back" suits which ended in injunctions against further "kick-backs" in 1951. These widely publicized suits brought out the fact that many medical refractionists received considerable sums annually from dispensing opticians, and this fact led the reading public to the conclusion that the "kick-back" represented an overcharge. Coupled with these Federal suits was the government's publicity concerned with the whole problem, which, too, made many patients very "price conscious" when it came to seeking visual care.

The third factor was the flood of press releases sent out by the Federal Social Security Agency plugging for Compulsory Health Insurance. The publishers of the country have received many of these since the latter part of 1948, and the flow of this material on behalf of socialized medicine continues from this Washington Agency. All of this unusual propaganda stresses the high cost of health care of which visual care is a part.

The fourth factor, which contributes to the feeling of unrest on the part of the public regarding the cost of visual care, is the rather large number of persons who are served by institutional eye care programs, or industrial programs in which the ophthalmic materials are

dispensed at laboratory cost. In the larger metropolitan centers nearly every family knows someone who works in a plant where ophthalmic materials can be secured at cost through a plant contract with an optical laboratory. It is claimed that a large eastern optical company, which does no business with optometrists or ophthalmologists, has hundreds of such industrial accounts serving these by mail, direct to safety or medical departments in industry.

The fifth, and last, major factor is those necessary programs which assist the indigent. These are largely locally controlled at present and, in many of these, the optometrist does the examining and refracting, and the County Welfare Board has the prescription filled for the patient. In most of these programs, no effort is made to conceal from the patient the cost of his materials as they come from the laboratory.

These major factors, and a number of minor ones not mentioned, have, over the years, brought about the feeling that visual care was unduly costly, and that those working in this field were guilty of charging excessive fees. Actually, the opposite was the case—and optometrists are in need of greater remuneration than that received under present plans dealing with professional fees.

During this same 20 year period, optometrists materially improved their refractive ability and knowledge of their work. They also vastly improved the professional surroundings in which they worked. Educational qualifications were raised and, in addition, the men in the practice changed their mental outlook regarding their work from selling glasses to supplying first quality visual care. The 20 year change in the scientific and technical ability of the optometrist in practice has been phenomenal, and this change, coupled with his professional attitude, *now* requires a review and a change in the now completely outmoded fee structures which have failed to keep pace with the educational and professional practice changes already accepted in optometry.

THE PROPOSAL

The writer proposes the following simplified suggested minimum fee structure for all optometrists in individual practices.

The following proposals have been time-tested in a number of optometric offices for a considerable period, and have proven not only satisfactory to the optometrists who have used them on an experimental basis, but also to their patients whose response has been excellent. In addition, the plan, when followed, improves the optometrist's financial position.

The plan consists of only three parts. It is simple, and can be

explained to the patient who will remember it in most instances. It is logical. It removes the objections to the present *one fee system* with its obvious over-emphasis on the high cost of materials.

PART I.

Each optometrist establish, for himself, a **minimum** fee for his examination and refraction. As a rule, this minimum fee should be $10.00. Some will want a higher minimum. No examination and refraction should be made for less than this minimum fee.* It is highly important in following this proposal that, if the suggested plan is adopted, it be adopted for all patients who are expected to pay for the services supplied by the optometrist. The plan cannot be put into effect for some patients and not others. Either your services, as an examiner and refractionist, are worth the minimum fee of $10.00, or they are not. This the reader must decide for himself. A competent optometrist, practicing in a professional environment, should, in the year 1952, have the confidence in himself to universally charge a minimum examination and refraction fee to any and all patients. When he does, the optometrist will find that his patients have greater respect for him, and that his professional standing in his community will improve. Many minimum fees will exceed $10.00.

With a minimum fee of $10.00, it must be understood that the examination and refraction fee for cases in which one or more post-refractions must be made would increase to $15.00 or $20.00 or $25.00. All refractions resulting in prismatic corrections, trifocals, field charting, subnormal visual aids or out-of-the-ordinary visual care should not enjoy the minimum fee of $10.00, but should be charged at least a fee of $15.00 or more.

PART II.

After the examination and refraction has been concluded, and the patient has been made aware of the diagnosis and prognoses, the optometrist then moves into the dispensing phases of our work. If materials are being prescribed, a minimum dispensing fee of $5.00 is charged the patient for dispensing *each* pair of glasses worked upon by the optometrist, irrespective of whether or not a new frame is supplied for each pair.

PART III.

At this point, if it has not been done before, the patient is informed of the professional fee in his case. The examination and refraction fee of $10.00, or more, and the dispensing fee of $5.00.

*The only possible exceptions being charity patients or professional courtesy work from which no fees are expected or accepted.

The patient is then informed that the materials which must be prescribed are available to him at the prescription laboratory cost for the best materials which are available to the optometrist. If a new frame is required, the patient is shown samples, each clearly marked with the exact prescription cost to the optometrist of one such frame. This may be $3.15 or $5.65 or $8.30, depending on quality and style. Each frame should be clearly price marked.

After the patient has selected a new frame, the cost of the lenses are also computed at the prescription laboratory cost of lenses inserted in frames at the laboratory. No round figures are used. The exact prescription charges are the figures used in computing the patient's bill for materials. To the above figures are added the cost of a case, and the cost of postage and insurance, if the materials are mailed to the optometrist by the laboratory. The patient is then informed that the necessary materials will come to a total of $7.10, or $9.25 or $11.65 or $16.65, depending on the exact laboratory cost of the materials. For those patients using their own frames, the cost to the patient would be the prescription cost of the lenses only, inserted in the patient's frame, plus postage and insurance, if any. Where necessary, a sales tax is added to the cost of materials only.

At this point, the optometrist informs the patient that for this particular amount, computed for the patient from sample frames with price tags and from laboratory catalogues, the optometrist will purchase the required material for the patient.

As it must be purchased from a laboratory and, as it is being prescribed at the exact laboratory cost, the patient is expected to pay for it at once, or at the latest, when the materials are finally dispensed to the patient. This being agreeable to the patient, the optometrist then takes the facial measurements and writes up the prescription order for the laboratory. The patient, at this point, understands that two bills have been, or will be, presented. The first is for the examination and refraction fee, plus the dispensing fee. The second is for materials only. Some optometrists, using this suggested plan, have the patient make the check for materials out directly to the laboratory, leaving no doubt in the patient's mind as to what the materials cost and what professional fees the optometrist is collecting for his work.

DISCUSSION

In using the plan suggested, it is evident that the only income the optometrist actually receives is from his professional fees. The sums he collects for materials are merely held by him until the end of the

month, and are then used in their entirety to pay the laboratory, or laboratories, from which the materials have been purchased by the optometrist. A record should be kept of these, of course.

The plan, as proposed, is simplicity in itself. The materials are completely divorced from the professional work in the mind of the patient, as a separate and distinct charge is made for these. In addition, the optometrist receives a separate and clear cut fee for the knowledge and skill required of him in doing his dispensing work which will, in part at least, compensate him for this time consuming, though necessary, activity.

It is equally obvious that this plan will work to the greatest advantage in the offices of optometrists who practice professionally. Fees from professional services are difficult to rationalize in commercial surroundings, either by the optometrist or the patient. In optometry, the trend away from commercial activities is strong—those optometrists still in commercial practices will find this proposal a further stimulant to redesigning their practices to bring them in line with modern concepts of professional practice.

The question of repairs to glasses which have been broken naturally arises. For one's own patients this necessary work is done at the exact laboratory cost, irrespective of what that might be. The dispensing charge of $5.00, which was collected when the materials were dispensed in the first place, was intended to cover not only the initial dispensing, but such additional adjusting services as would be required until it would be necessary to again prescribe for the patient. Most patients return to their own optometrist when their glasses are broken.

For the occasional newcomer, with a pair of glasses needing repairs, the optometrist should do the work for these patients at the exact cost to him, and inform the patient of this fact, and of how his fees and charges are arrived at. In most of these repair situations, the office girl can do the work required, and in those cases, the only charge made to the patient is for materials at the exact laboratory cost. If the optometrist is called upon to make either minor or major adjustments on these non-refractive patients, and perhaps to take facial measurements, a dispensing fee for this non-refractive patient is now justified. This fee should vary from $2.00 to $5.00, depending on the time consumed in doing the work. No dispensing fee of less than $2.00 should ever be made, as professional men are not expected to divide their fees into lesser amounts than this.

Should a patient order a second pair of glasses, or should a patient return to have the original prescription refilled in a second pair of

glasses, the dispensing fee of $5.00 is again charged, as the entire work of taking frame measurements and adjusting the new frame must again be done. The fee for dispensing is the same when the patient's own frame is used as it, too, must be refitted. In these cases, the patient is presented with a professional dispensing fee statement in the amount of $5.00, and a second statement covering the exact cost of the materials used in the second pair of glasses.

The reader is, no doubt, wondering at this point just where he would stand financially if his practice were conducted along the lines suggested. It is a good point—one which must be raised—and one which requires a forthright answer.

As a rule, the optometrist will find that both his fees* and net income have materially increased after adopting the proposals outlined in this report. The reasons are: (1) that in most practices today, the simpler cases (which are the majority in number) are not producing the fee revenue suggested in this report, and (2) the plan here presented automatically collects the cost of materials at least—at the time the work is done. It eliminates the problem of the optometrist carrying considerable amounts on his past due accounts receivable lists for materials which he has had to furnish for the patient.

In presenting the specific answer to this question, a hypothetical, yet typical, practice will be used—a practice in which the optometrist averages two refractions each day. This is not a large practice, and would certainly include most of the professional practices of the country.

For simplicity, we will also assume that *only* the minimum examination and refraction fee of $10.00 is collected from each of these patients, and that none of these patients orders more than one pair of glasses. It is also assumed that a prescription is written and dispensed for each patient. No attention is given to special fees for orthoptics and other special services.

On the above basis, the annual gross income of this optometrist—(exclusive of the amounts collected, held and paid out monthly for ophthalmic materials to the laboratories) will be $9,360.00. This sum represents the fees charged his patients. (A minimum examination and refraction fee of $10.00 and a dispensing fee of $5.00 to each of the 664 patients examined and refracted during the year.

From this total of $9,360.00 must now be deducted his operating costs. We will assume that his office rent is $100.00 per month. His telephone is $15.00 per month. His electricity is $5.00 per month.

*The writer is aware that some optometrists secure larger fees, but we also know many who do not. The suggestion for a minimum fee of $10.00 is for this latter group only. Others would have a minimum fee of $12.00, $15.00, $18.00 or $20.00, in addition to the dispensing fee.

and he pays his receptionist $175.00 per month. Experience with those already using this plan indicates that, in professional optometric offices, the credit loss on fees is never more than two per cent.*

Deducting the annual rent, telephone, light and receptionist's salary from the gross figure of $9,360.00, we find the optometrist left with $5,820.00. Deducting from this amount two per cent of the total gross for credit losses, leaves the optometrist with a net, before taxes, of $5,632.80.

Actually, his net will be considerably more. Many of his cases will require more than minimum services, and he will collect many examination and refraction fees in excess of the minimum of $10.00. In addition, a fairly large number of patients, finding their needed ophthalmic materials so reasonably priced, will order one or two additional pairs of glasses, thus increasing the dispensing fees collected by the optometrist. If orthoptic or other specialized work is done, the fees for this service will further augment the optometrist's income.

SUMMARY

1. The author has proposed a simplified fee system for optometrists in professional practice. A minimum examination and refraction fee of $10.00 is proposed. In cases requiring specialized or unusual care, fees larger than the minimum are suggested.

2. A minimum dispensing fee of $5.00 for each pair of glasses dispensed is also suggested.

3. It is further suggested that all ophthalmic materials be dispensed at the prescription laboratory cost to the patient.

4. It is further suggested that the patient be presented with an individual statement for professional fees, i.e., examination and refraction fee, minimum of $10.00, plus dispensing fee of $5.00, if materials are dispensed.

5. In addition, it is suggested that all laboratory materials be collected for in full at the time the material is ordered, as this material is being dispensed to the patient at cost, and the optometrist should not, and cannot, carry any of these costs or charges on his open accounts.

6. Under the plan as presented, the optometrist who averages two refractive cases a day will have a minimum net income, after all legitimate operating bills are paid, of close to $500.00 per month.

CONCLUSIONS

Optometry is rapidly assuming full professional stature. Its educational requirements and the professional character of the work done by optometrists now requires that its fee structure be adjusted to

*In most offices it is less than one-half of one per cent.

eliminate the suggestion of, or criticism because of, profiting on the sale of materials. Optometrists' incomes should consist of professional fees only. These fees must not be hidden or confused with the cost of materials to the patient. The plan, as proposed, adjusts the fee structure to accomplish these ends.

☆ In adopting these proposals, the specific advantages to the *Profession of Optometry* are:

(a) Optometry would join the ranks of medicine, law and veterinary medicine as a professional calling receiving all income from professional fees.

(b) On a purely fee basis, optometry would remove the stigma now associated with selling glasses.

(c) The current fee system now in use in optometry places the ethical optometrist at a disadvantage when his present one overall charge is compared with that of the outright commercial optometrist. The plan, proposed, entirely eliminates this disadvantage.

(d) The anti-optometric activities of some optical dispensers also places the ethical optometrist at a disadvantage when his present one, overall charge is compared with that of the dispensing optician. The plan proposed eliminates this disadvantage.

(e) The plan as proposed, in which the profession relies on fees only, places optometry in a more advantageous position to overcome the problems inherent in Compulsory Health Insurance, if this program should be adopted.

(f) The plan as proposed, keeps control of the entire service in the hands of optometry, but eliminates the disadvantage of the present system of one overall fee for services, dispensing and materials.

☆ In adopting these proposals, the specific advantages to *the optometrists* are:

(a) The plan as proposed, puts an optometric practice on an entirely fee basis. The optometrist practices and lives on fees alone.

(b) The plan as proposed, eliminates the ever present suspicion that one is prescribing materials because of the profit in so doing.

(c) The plan as proposed, eliminates all laboratory bills for materials, as all necessary money which is collected for materials is returned to the laboratories each month.

(d) The plan as proposed, eliminates delinquent accounts for materials, as these are all on a cash basis.

(e) The plan as proposed, eliminates the necessity of carrying

stocks of materials which rapidly become obsolete, and which tie up capital in a slow moving inventory.

(f) The plan as proposed, adequately compensates the optometrist for his examination and refraction work.

(g) The plan as proposed, adequately compensates the optometrist for his work in dispensing.

(h) The plan as proposed, will add from 20 to 30 per cent additional patients with extra pairs of glasses for special purposes or emergency use.

(i) The plan as proposed, makes patients more willing to return for re-examination when this is indicated.

☆ In adopting these proposals, the specific advantages to *the patient* are:

(a) The patient knows and understands, and, what is even more important, respects a professional fee.

(b) The plan as proposed, informs the patient as to the exact cost of the required materials.

(c) The plan as proposed, makes the cost of supplementary pairs of glasses most modest, and the cost understandably clear to the patient.

(d) The plan as proposed, reduces the cost of repairs to the patient when needed.

(e) The plan as proposed, removes the suspicion of profit merchandising on materials.

(f) The plan as proposed, makes it possible for the patient to accept with confidence the advice of the optometrist as the patient knows that the optometrist has little to gain from the prescribing of ophthalmic materials.

☆ In adopting these proposals, the specific advantages to *the laboratories* are:

(a) The plan as proposed, gets the optometrist's account on a cash discount basis and keeps it there.

(b) The plan as proposed, eliminates the problem of exchanging frames, as optometrists would have samples only in their offices.

(c) The plan as proposed, would stimulate the use of only the finest materials, as there would be little or no advantage to either the patient or the optometrist in using anything else.

(d) The plan as proposed, would discourage optometrists from shopping around for "bargain" materials, or sending their prescription work to cut-price laboratories.*

*Part II of this report dealing with Suggestions for a New Fee Structure in Optometry will appear in the August issue. In this portion of the report the author will answer the most frequently asked questions regarding this new fee schedule.

MAGNIFYING EFFECTS OF SPECTACLE LENSES*

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It is not generally appreciated how important magnification relationships can be in the case of ordinary ophthalmic lens corrections. Workers in the field of aniseikonia have long been aware of the problems involved, but general practitioners have been wont to ignore the "per cent or two" differences induced by their prescriptions. That this "ignorance" is to blame for many of the complaints of spatial distortion and discomfort by patients may be justly inferred from the following discussion.

For the sake of simplicity, this treatment will be limited to the optics concerned with distance corrections, wherein the secondary focal point of the correction lens is made to coincide with the far point of the ametropic eye. The unwarranted assumption that spectacle lenses are infinitesimally thin will not be made. Since the correction lens does not in any way change the optical constants of the static eye itself, we can simply define the magnifying power, M, of any optical system as the ratio of the angular size, $\bar{\omega}$, of the image seen by the eye when corrected, to the angular size, ω, of the original, infinitely distant object.

In short, $M = \frac{\bar{\omega}}{\omega}$.

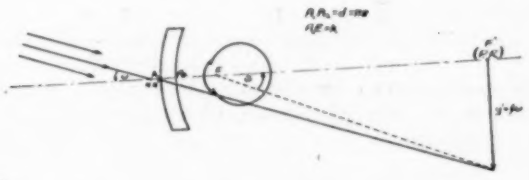

Fig. 1.

Figure 1 illustrates the situation for a hyperope and inspection shows at once that $\bar{\omega}$ will be larger than ω, resulting in a magnification

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greater than unity. It can easily be seen that $\omega = \frac{y'}{f} = yF.$, where y′ is the size of the image in the far point plane and F is the equivalent refracting power of the spectacle lens. The vertex power of a spectacle lens, which is the reciprocal of the back focal length, is given by the well-known expression, $V = \frac{F}{1 - cF_1}$, wherein c is the reduced thickness $(\frac{d}{n})$ of the spectacle lens, and F_1 is the power of the first surface. Only if c or F_1 equals zero will $V = F$.

Now, we may write:

$$(1) \quad \omega = y'F = y' V(1 - cF_1) .$$

From Figure 1, it may also be seen that $\bar{\omega} = \frac{y'}{EF'}$. But $EF' = A_2F' - A_2E$, wherein A_2F' is the back focal length of the correction lens $(= \frac{1}{V})$, and $A_2E = K$ is vertex distance or fitting distance of the lens.

Therefore, we may write:

$$(2) \quad \bar{\omega} = \frac{y'}{\frac{1 - K}{V}} = \frac{y' V}{1 - KV} .$$

Dividing (2) by (1), we have:

$$(3) \quad M = \frac{\bar{\omega}}{\omega} = \left(\frac{1}{1 - KV}\right) \quad \left(\frac{1}{1 - cF_1}\right)$$

This is the exact formula for the magnification of a spectacle lens, expressed in terms of the tangible, measureable quantities c, F_1, k, and V. It may be of interest to note that the two factors have important meanings individually. The first, $(\frac{1}{1 - KV})$, can be called "power factor," and gives the magnification due to an infinitesimally thin lens. The second, or "shape factor," $(\frac{1}{1 - cF_1})$, gives the magnification due to a telescopic or afocal system, like an iseikonic or "size" lens or zero refracting power. Thus, the important conclusion may be drawn that any spectacle lens may be considered to consist of an afocal

lens in contact with infinitely thin refracting lens whose magnifying powers are multiplicative.

For computational purposes, equation (3) may be put into a much more convenient, though approximate form. This is based on the fact that $\frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots$, an infinite series that results either from the Binomial Theorem, or from the algebraic division of (1) by (1—x). If x is considerably smaller than 1, this series is rapidly convergent, and terms of the second and higher degree may be neglected without appreciable loss of precision. Alternatively, multiplying numerator and denominator of the fraction $\frac{1}{1-x}$ by $(1 + x)$, we get $\frac{1}{1-x} = \frac{1+x}{1-x^2}$. If x is much smaller than one, as before, x^2 in the denominator can be neglected, and $\frac{1}{1-x} = 1 + x$. (Numerically, we often have made this approximation unconsciously. Thus $\frac{1}{0.997} = \frac{1}{1-.003} = 1\frac{3}{997} \cong 1.003$.)

Consequently, applying this approximation to both factors in (3), we get $M \cong (1 + cF_1)\ (1 + KV) \cong 1 + cF_1 + KV + cF_1\,KV$. The last term here can usually be neglected, being an infinitesimal of higher order, or the product of two small factors. In the expression, $M \cong 1 + cF_1 + KV$, c and K are expressed in meters, and F_1 and V in diopters. In ophthalmic practice, and especially in aniseikonia, M is usually expressed in percentage, so that, for instance, $M = 1.035$ becomes $M\% = 3\frac{1}{2}\%$. Therefore, our final, convenient and extremely useful relationship is:

(4) $M\% = cF_1 + KV$, wherein F_1 and V are still measured in diopters, but c and K must be expressed in centimeters.

With four variables at our disposal, there exists quite a bit of leeway in the possible range of magnification. The values of c and F_1 are most easily alterable, although often at the expense of departure from the ideal anastigmatic or corrected curve form. The fitting distance K can be varied slightly, but physiognomic considerations like the depth of the bridge of the nose and the length of the eyelashes impose limitations. The vertex power is relatively inflexible, dependent as it is upon

the refractive condition of the eye and varying so minutely with the distance K.

Equation (4) can be used repetitively to compute how the spectacle magnification changes when one or more of the variables is changed. A useful approximation, based upon differential calculus, is:
(5) $\Delta M = c\ (\Delta F_1) + F_1\ (\Delta c) + K\ (\Delta V) + V\ (\Delta K)$.
This gives us the approximate increase or decrease in magnification in one step, rather than requiring separate computations for each set of conditions.

Practically speaking, we are less interested in M than in ΔM, because, in general, we do not know the original aniseikonic condition but are interested in the magnification changes induced by changes in base curves, thicknesses, and fitting distances.

Now, in order to put to practical use some of these relationships, we shall consider several typical magnification problems that often arise in clinical practice. We can assume that $n = 1.5$ for ease in numerical work in these problems.

Problem 1: A patient has been comfortably wearing a —4.00 D. sphere before his right eye and a —2.00 D. sphere before his left eye, with the shape, thickness, and fitting distance factors given in Table I. Assuming because of his comfort that this prescription is ideal and gives no unequal image sizes, what is the effect (aniseikonia induced) of making an extra pair of glasses with the same lens characteristics, but fitted 2 mm. farther from his eyes, i.e., changing K from 15 mm. to 17 mm.?

TABLE I

	R	L
V	—4.00 D.	—2.00 D.
K	1.5 cm.	1.5 cm.
F_1	+6.00 D.	+6.00 D.
$c = d/n$	$\frac{.12}{1.5} = .08$ cm.	$\frac{.15}{1.5} = .10$ cm.

Solution:

From equation (5), $\Delta M = c(\Delta F_1) + F_1\ (\Delta c) + K\ (\Delta V) + V(\Delta K)$, we see that the only variable to consider is K, since all the others are unchanged. Therefore $\Delta M = V\Delta K$ for each eye, and $\Delta K = 1.7 - 1.5 = 0.2$ cm. for both eyes.

$\Delta M_R = (-4.00)\ (0.2) = -.8\%$)
) Difference = 0.4%
$\Delta M_L = (-2.00)\ (0.2) = -.4\%$)

Thus, we see that the ocular image in each eye is reduced in size, but the left one less so, so that .4% of aniseikonia is induced by a mere

shift of 2 mm. in the fitting distance. With some persons sensitive to as little as ¼ % disparity, it can be seen that this effect might be quite pernicious.

Problem 2: A patient who has been happy with +5.00 D. spheres O. U. is found by a well-intentioned young refractionist to require an additional +0.25 D. cylinder at axis 90° before the left eye. When his prescription is filled in toric form as outlined in Table II, he finds it intolerable. Why?

TABLE II

	R	L (in 90th meridian)
V	+5.00 D.	+5.00 D.
K	1.5 cm.	1.5 cm.
F_1	+11.00 D.	+6.00 D.
$c = d/n$	$\frac{.36}{1.5} = .24$ cm.	$\frac{.36}{1.5} = .24$ cm.

Solution:

Applying equation (4) to each lens,

$M_R = (.24)\ (11.00) + (1.5)\ (5.00) = 2.64 + 7.50 = 10.14\%$)

) Difference = 1.2%

$M_L = (.24)\ (\ 6.00) + (1.5)\ (5.00) = 1.44 + 7.50 = \ 8.94\%$)

or, using equation (5),

$$\Delta M = c(\Delta F_1) = .24\ (5) = 1.2\%$$

Thus we see that the ocular image in the right eye is 1.2% larger than in the left. This, of course, applies only to the vertical meridian of the left eye. In the horizontal meridian, where F_1 would be +6.25 D, the magnification in the left eye would be slightly greater than 8.94%, by an amount equal to (.24) (.25) = .06%. This discrepancy could be ignored and we can reasonably claim that there is a 1.2% overall magnification in the right eye. This result does not imply that it is unwise to prescribe the 0.25 D. cylinder. Rather, the base curves and thicknesses should be adjusted so as to avoid unequal magnifications.

Problem 3: An eikonometric refraction indicates the following prescription:

R. +2.00 D.S.

L. +4.00 D.S. ⊂ +2.00% O.A.

The characteristics of the spectacle lenses with which the magnification requirements were determined are given in Table III.

How can this be achieved without using special iseikonic lenses? Solution: The desideratum is to increase M_L from its original value by 2%. The most practical way of doing this is to increase F_1 or c, or both, for the left lens. The original cF_1 value is (.2) (8) = 1.6%. We require a value of 3.6%. Any pair of values for c and F_1 for the

TABLE III

	R	L
V	+2.00 D.	+4.00 D.
K	1.5 cm.	1.5 cm.
F_1	+8.00 D.	+8.00 D.
$c = d/n$	$\frac{.3}{1.5} = .2$ cm.	$\frac{.3}{1.5} = .2$ cm.

left lens whose produce is 3.6%, therefore, will suffice. Thus, we have a choice of

$c = .3$, $F_1 = +12.$
$c = .36$, $F_1 = +10.$
$c = .40$, $F_1 = +9.$
etc.

The wisest selection would probably be the second, with a front curve of +10.D and a center thickness of $d = nc = 1.5(.36) = .54$ cm. = 5.4 mm, because it happens to be nearest the anastigmatic form, without differing too much cosmetically from the right lens.

The foregoing problems are merely indicative of the possibilities inherent in the methods outlined. Meridional magnification problems are handled simply by separate considerations of the effects in the principal meridians. In certain cases, bitoric lenses may be necessary in order to obtain overall plus meridional magnification. Certain tricks may be resorted to for special requirements. For instance, if a sphero-cylindrical lens is required to give overall magnification rather than meridional, it is possible to have it ground with the cylinder on the rear surface, so that the cF_1 term will give overall magnification. Again, if changes in K may effect a solution to a given problem without changes in the lens itself, or in the fitting of the frame, special beveling may be the answer. Thus, it is easy to see that, in the case of a high minus lens, beveling the edge nearer to the front surface will decrease K, sometimes by several mm., and conversely. In the absence of eikonometric equipment, judicious guesses may often be made, based upon ophthalmometer readings.

As an example, if one eye is emmetropic, and the other myopic, but both corneal readings are the same on the ophthalmometer, it seems reasonable to assume that the myopia is axial and that the unaided myopic eye receives a larger, though blurred, image than the emmetropic eye. Thus, assuming the refracting power of the normal eye to be 60 diopters, an axial myopia of 3 diopters would imply an image larger by $\frac{3}{60} = 5\%$ than for the emmetropia. This magnification will be partially, at least, offset by the KV term when the proper correction is prescribed.

PINHOLE CONTACT LENSES*

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Recent advances in the art of making plastic artificial eyes have made it possible to incorporate the principle of pinhole spectacles into a pair of contact lenses. The procedure is highly exacting, time-consuming and expensive, but in the rather rare case where it is indicated, the results are extraordinarily gratifying.

The pinhole contact lens consists of a prescription contact lens into which has been incorporated a colored artificial iris with a small artificial pupil. My own experience has been that the smallest practical pupil size is 2 mm. This is small enough to correct most presbyopia without unduly restricting the visual field, although in one case I have used a 1 mm. pupil.

There is no novelty in the incorporation of an artificial iris into a contact lens. In its simplest form such a contact lens may be used instead of an artificial shell eye to cover an unsightly blind eye. It is molded on the basis of an impression of the eyeball and no optics are incorporated into the lens. Such a "lens" is designated as a *Cosmetic contact lens or a cover contact lens.* Actually, *it is not a contact lens at all,* but a highly refined and accurately fitted *reform shell eye.* The scleral section of the cosmetic lens is made opaque, and the corneal section can be decentered with the consequent result that a squint can be concealed quite effectively. The cornea and pupillary section of the cosmetic contact lens is opaque. Obviously, this lens is used only when there is either no vision in the eye wearing the lens or where the vision is deliberately occluded by means of the lens.

In cases of albinism, semi-albinism, dyscoria, particularly polycoria (i.e., the presence of two or more pupils in the same iris, resulting usually from trauma of the iris) the use of a *prescription cosmetic contact lens* is indicated. This lens is identical with the reform shell types of contact lens in that the entire lens is opaque except for the pupillary zone, which is transparent, and into which is incorporated the ametropic correction. This lens is doubly effective in cases of albinism

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and semi-albinism in (a) eliminating either completely or to a large extent the photophobia which is normally present; and (b) improving the visual acuity, which is otherwise reduced through the absence of an effective pupil.

In cases of polycoria, multiple images are seen monocularly because of the presence of more than one pupil. Single monocular vision is restored in such cases by the elimination of all but one pupil by means of the prescription cosmetic contact lens.

The incorporation of a colored artificial iris into a contact lens is climaxed in the *prescription cosmetic contact lens* in which the artificial pupil is reduced in size to pinhole proportions, with the resulting increase in the visual acuity which may be produced under favorable circumstances. Such a lens may best be designated as a *pinhole contact lens*.

Even before the development of the artificial eye making techniques which have since led to the successful construction of pinhole contact lenses, it was predicted that such lenses could be used by presbyopes and would afford them universal focus.

These predictions were confirmed even by the rather crude techniques which were made available some years ago, although the technical imperfections of earlier pinhole contact lenses limited their use to a very small number of patients who could achieve the tolerance to wear them. The early prescription cosmetic lens had two serious defects, which resulted from the technique used of painting an artificial iris directly on the rear surface of the contact lens. The necessity of providing additional clearance on the back surface of the lens in order to provide room for the art work resulted in a bulging of the cornea. This bulging was not only unsightly but introduced a gravity drop and a variable decentration which necessitated the use of a relatively large pupil and too thick a water lens with resultant prismatic disturbances. The second defect resulted from the fact that since no paint could be found which would resist the action of the tears, the art work had to be done over within 12 to 24 months.

The newest techniques which are now available make it possible to inlay the artificial iris into the body of the contact lens, so that it is surrounded by plastic. As the painted iris can no longer touch the eye itself or come in contact with the tears which have a corrosive effect on the paint, the colors remain fast. The extra corneal clearance which previously produced bulging is no longer needed, so that the new type lenses are now flatter and well centered.

The writer has used these lenses with very good results in cases of albinism, polycoria, keratoconus, and presbyopia.

The case of Mr. B, a lawyer, who was first referred to me about a dozen years ago, demonstrates in a most dramatic fashion the potentialities of the pinhole contact lens.

When Mr. B. was first referred to me, he was about 35 years old and was wearing a +7.00 D. cylinder over one eye and a +10.00 D. cylinder over the other. His visual acuity was approximately 20/100 in each eye. His condition had been diagnosed as irregular astigmatism which was confirmed by the fact that contact lenses gave him 20/20 in each eye. The possibility of keratoconus was considered. However, conclusive evidence of keratoconus was not found until some years later. Despite the fact that progression of keratoconus is rare when contact lenses are worn, Mr. B. gradually suffered a loss of acuity. This was first associated with the onset of presbyopia, but was further complicated by the presence of vitreous opacities. After Mr. B had worn his lenses for about six years, his visual acuity was reduced to about 20/40 in each eye both at far and at near. The necessity of using short focal length reading glasses, together with nervous worries about the continuous failure of his sight, produced a gradual state of mental disorganization in the patient. One of his principal fears was that he was blocking his chances for advancement in the firm for which he was employed by his being forced to read at a distance of a few inches, and that before long he would become completely unemployable unless his normal acuity could be restored by some inconspicuous device.

A single pinhole contact lens with a 1 mm. pupil was made for Mr. B, and proved to be unsatisfactory, due to the undue restriction of his field. Another lens was made with a 2 mm. pupil, with the aid of which Mr. B was able to read ordinary print without reading glasses, and the smallest fine print with his normal near point add.

Almost a year was spent in arriving at the final result. A number of lenses were made and discarded before the problem of placing the artificial pupil in exactly the right spot was solved: and even after an ideal result was obtained optically, after a few weeks Mr. B. rather apologetically requested that the job be done again in order to improve the color match. A new technique was then developed, with the aid of which Mr. B's problem of getting a good color match was then solved.

Mr. B's own comment on the pinhole contact lens was that he felt that it was as much better for him than the regular contact lens he had been wearing, as the regular contact lens was better than his spectacles.

The procedure in the fitting of the pinhole contact lens is as follows:

1. Using either the eye impression technique (which I favor),

or the trial case technique using full-size contact lenses, the physical fit of the final lenses is approximated in the semi-finished form without concern for the optics.

2. A tentative prescription is determined by whatever means are most suitable in the individual case. It may be necessary to expend a prescription lens in the process, although to a limited degree regrinding of the finished pinhole lens can be done. Before doing so, it is advisable to estimate with the aid of a prescription trial lens the approximate prescription needed for the patient, as is conventionally done in contact lens practice. In those cases where an acute need for a pinhole contact lens is present, as in polycoria or dyscoria, it is of great advantage to be able to refine the prescription by the use of a suitable pinhole device before making the final decision.

It is at this point at which we have introduced a slight innovation in the art. In the earlier days of contact lens work, a pinhole effect was created by darkening the iris section of the lens with a black wax pencil, such as a cellophane marking pencil. The technique was very poor, inasmuch as it was impossible to get an adequately opaque coat of wax on the lens. From the marked lens a final lens would be made on the basis of the estimate as to the distance and direction that the lens had to be pushed on the eye to center properly.

The aggravating problem of centration is solved in the simplest possible fashion by means of a *contact lens pinhole disk* which I have designed, but not patented, and which you may freely use. The contact lens pinhole disk is a thin shell of black plastic about the size of the corneal section of a contact lens and with about a 7½ mm. inside radius of curvature. It is pierced at the center with a circular aperture 1 mm. in diameter. A similar disk with a larger pupillary aperture of 2 mm. or 3 mm. is useful in determining the most favorable position of the artificial pupil to be put into a prescription cosmetic contact lens.

Since the contact lens pinhole disk is freely movable over the front surface of the contact lens worn by the patient, it is a comparatively simple matter to determine the most favorable placement of the disk. After this has been done, the center of the pinhole disk, or the perimeter of the artificial pupil, can be spotted on the contact lens which is being worn by the patient, using a sharply pointed cellophane marking pencil. The lens can now be duplicated by a good laboratory, with a high degree of accuracy in the duplication of the centration chosen by the doctor for the patient. Mr. Albert Anderson of Precision-Cosmet in Minneapolis has pioneered in this field.

It is necessary for the doctor to furnish to the laboratory not only the suitably marked, semi-finished lens, together with the final prescription, but also the data required for the laboratory to achieve a good color match in making the artificial iris.

The most successful method for obtaining a color match is to have an artist accustomed to working with artificial eyes paint from life an exact replica of the iris of the patient's other eye on an iris disk used by the artificial eye maker. This is then sent along to the contact lens manufacturer.

An alternative method, which will produce a satisfactory, but rarely a perfect result, is to have the doctor pick out a stock artificial eye that gives a reasonably good color match, send this to the laboratory, and have them send back a couple of dozen iris buttons in the same color group, with the aid of which a more exact match can be made. The button is identified and is used by the laboratory in making the final lens. It is not surprising that it may be necessary for the laboratory to do the job over two or three times before the doctor and the patient are satisfied. A case should not be undertaken, therefore, unless the patient will allow a sufficient length of time to carry it through to a good result.

There is no question that pinhole contact lenses afford the greatest challenge that the contact lens expert ever has to face, at least in terms of the technical difficulties of designing and fitting of contact lenses, and the time and care and patience which he must unstintingly lavish on the case. Much the same can be said concerning the technical difficulties involved on the part of the laboratory in the manufacture of the lenses. Consequently, a successful case is extraordinarily gratifying to everyone who participates in it. For the laboratory, a successful pinhole contact lens case is a tribute to not only the utmost in precision and skill in lens making which the lens represents, but it also is a tribute to a professional spirit in which the laboratory shares as a partner on the case. If the laboratory were to charge at its usual rates for the time and skill expended in the manufacture of the lens, the cost of the lens would be prohibitive. That it does not do so, makes it possible for the doctor to bring the lens to the patient at all.

For the doctor, a pinhole contact lens case for a subnormal vision patient represents one of the high points of his career, not only because of the gratitude and appreciation which his patient gives him, but because of the satisfaction which the completion of an extraordinarily difficult job brings with it.

And finally, for the patient, it is difficult for those who have not

worked with subnormal vision patients to appreciate how much even a small improvement in vision means to them. Quantitative measurements are deceptive. We are prone to think of 20/200, which is the usual legal limit of blindness, as being approximately equivalent to physiological blindness. But when we are able to bring a patient with finger-vision up to 20/200, as on occasion many of us have done, we discover that it is the relative improvement, rather than the absolute magnitude of the patient's vision, which is significant: and that we have done far more for him than we would have done, had we started with 20/200 and brought him up to 20/20.

Obviously, all the rewards of subnormal vision rehabilitation work are afforded in pinhole contact lens rehabilitation work. However, if I may generalize from the very small number of cases which I have handled in pinhole contact lens cases, the recurrent delays which drag the case out, the novel problems which arise, the tantalizing misses which give promise of better results without achieving them, add a suspense to the case which seems to heighten and make richer the satisfaction which is achieved when the case is finally successful.

NEW BOOKS RECEIVED

Text-Book of Ophthalmology. Volume 5. The Ocular Adnexa, by Sir Stewart Duke-Elder, K.C.V.O., M.A., LI.D., D. Sc. (St. And.), Ph.D. (London), M.D., F.R.C.S., 1082 pages, 1181 illustrations, 32 in color. Published by the C. B. Mosby Company, St. Louis, Missouri, $22.50, 1952.

Rx for Medical Writing, by Edwin P. Jordan, M.D., and Willard C. Shepard. Published by W. B. Saunders Company, Philadelphia, Pennsylvania, 112 pages, 26 illustrations, cloth. 1952.

Proceedings of the London Conference on Optical Instruments. Held at the Imperial College, London, July, 1950. (21 papers dealing with photographic and projection lenses, microscopes and other optical instruments). Published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, New York. 264 pages, illustrated, cloth. $7.00. 1952.

Principles of Refraction, by Sylvester Judd Beach, AB, M.D., F.A.C.S. Published by The C. V. Mosby Company, St. Louis, Missouri. 158 pages, illustrated, cloth. $4.00. 1952.

THE RELATIONSHIP BETWEEN GEOMETRICAL PERSPECTIVE AND STEREO CUES*

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INTRODUCTION

In a previous paper,[1] a theory was formulated as to the relationship between physical distance and perceived distance as applied to points on the perpendicular bisector of the base line connecting the centers of the two entrance pupils when the two eyes are converged on a point on this line. When this paper[1] was published it was without awareness that Helmholtz[2] and Von Kries[3] had already formulated a similar theory.

One of the basic assumptions underlying the theory is that the relationship between perceived distance and physical distance is learned, and in order for perception of distances within arm's length to serve any useful purpose, perceived distances must be in reasonable agreement with actual distances.

In order for an observer to judge correctly the distance between two points on the perpendicular bisector of the base line, he must react simultaneously to cues of retinal disparity, and to cues of the absolute distance of the point of convergence. Allowance must also be made for the possibility that in a given situation the perceived distance of the point of convergence may not correspond to the physical distance. Accordingly it has been assumed that the perceived distance of an object P is given by the following equation

$$\rho = \frac{1}{\frac{(\gamma - \bar{\gamma})}{a} + \frac{1}{\bar{\rho}}} \qquad (1)$$

where $\bar{\rho}$ is the perceived distance of an object at the point of convergence $\bar{P}$ and $(\gamma - \bar{\gamma})$ is the difference between the binocular parallax of P and that of $\bar{P}$. See Figure 1. This difference in binocular parallax is proportional to the disparity between the retinal images of P and the images of $\bar{P}$. Equation 1 reduces to

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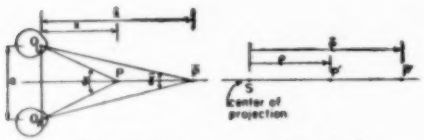

A PHYSICAL SPACE B VISUAL SPACE

Fig. 1. The relationship between physical space and visual space for points on the perpendicular bisector of the base line connecting the centers of the entrance pupils of the two eyes.

$$\frac{1}{\rho} = \frac{1}{x} + \left(\frac{1}{\rho} - \frac{1}{x}\right) \tag{2}$$

where the term $\left(\frac{1}{\rho} - \frac{1}{x}\right)$ is a constant and may be designated by k for a given situation.

$$\frac{1}{\rho} = \frac{1}{x} + k \tag{3}$$

Furthermore, the perceived distances of points along the perpendicular bisector must be independent of the point of convergence; that is to say, as the convergence jumps along the bisector from point to point, the perceived distance of a point about to be fixated does not change when the eyes actually converge on the point. This means that not only does Equation (3) hold for a given point of convergence, but also

$$\frac{1}{\rho} = \frac{1}{x} + k \tag{4}$$

holds for a given series of convergence points along the bisector, that is, for a given group of objects and background presented to the eyes.

In accordance with Equation (3) or Equation (4), perceived distance is equal to physical distance when $k = 0$. Figure 2 shows the relationship between perceived distance and physical distance for various values of k. This figure shows that one can assume a rigid correspondence between perceived distance and physical distance for objects within arm's length, not only for a zero value of k, but for small values of k which involve considerable error in the judgment of distances of remote points.

BASIC FACTORS IN GEOMETRICAL PERSPECTIVE

It is desired to limit this discussion of the relationship between

stereopsis and geometrical perspective to two aspects of geometrical perspective: namely, (1) the apparent convergence of parallel lines which are not parallel to the picture plane, and (2), the spacing of lines

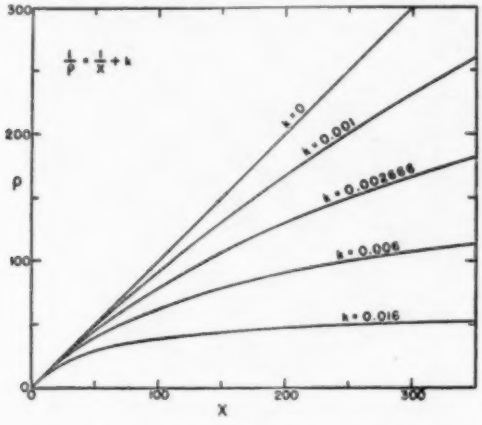

Fig. 2. The relationship between x and p for the various values of k.

parallel to the picture plane. In Figure 3, the lines connecting the points on the two squares all converge at a common point E. It should be noted that this convergence without the assistance of other cues does not constitute a very strong determinant of the relative distances of the small and large squares. The pattern may be perceived as a rectangular hallway with parallel sides, and with parallel floor and ceiling. On the other hand, the figure may be perceived as perfectly flat, or as the inside, or as the outside of a truncated pyramid.

The quadrilateral figure HFGK may be perceived either as a square or as a non-rectangular quadrilateral. All of this is in accordance with the principle described by Bartley[4] and called by him the principle of *geometric equivalence*.

One important principle that needs to be emphasized is that a straight line which is oblique or normal to the picture plane is perceived to be a straight line. It follows, therefore, that when a figure like that in Figure 3 is perceived as a rectangular figure having parallel sides and parallel ceiling and floor, the point of convergence of the converging lines must lie at an infinite distance. Consequently, visual space so far as geometrical perspective is concerned does extend to an infinite distance from the eyes.

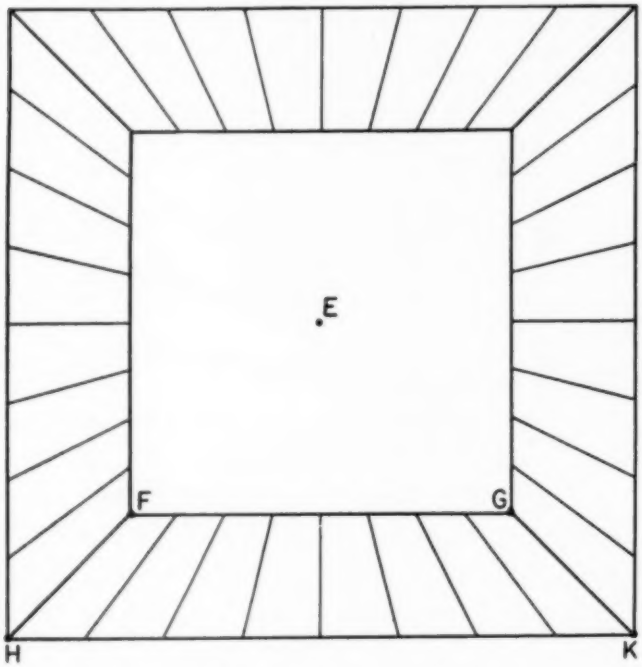

Fig. 3. Figure for demonstrating the role played by lines converging on a vanishing point. When viewed with one eye from a distance of 15 cm. at a point on the line perpendicular to the picture plane at E, this figure represents a cube.

In the discussion above, no attempt is being made to ignore the fact that under certain circumstances a straight line may be perceived as curved, or a curved line may be perceived as straight. This sort of thing happens in the Hering illusion which is illustrated in Figure 4,

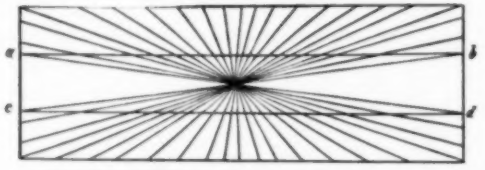

Fig. 4. The Hering[5] illusion.

and in Helmholtz' familiar figure (Figure 5) which if viewed at the

Fig. 5. Helmholtz' figure[6] for demonstrating the barrel distortion of the eye. When viewed at the proper distance the curved lines appear straight.

proper distance will appear composed of straight lines. These phenomena in no way vitiate the general principle outlined above.

If the observer becomes beset with the idea that the two squares in Figure 3 are actually of equal size, this will cause the two walls and the floor and ceiling to appear parallel. When this happens, the perceived distance between the two squares will be effected by the distance of observation. This effect can be avoided by using a single square and a set of lines converging on a vanishing point as shown in Figure 6. In this instance, any relationship can exist between the perceived distance of the point of convergence and the plane of the square.

If Figure 7 is viewed from a distance of 15 cm. it is perceived as a cube and the parallel lines on the walls, ceiling and floor appear equally spaced. The depth effect achieved by this figure is much stronger and more fixed than that achieved with Figure 3. The tendency to see the lines as equally spaced and squares of equal size dominates the situation.

If one views the figure from a greater distance than 15 cm., say 30 cm., which is just double the distance, the cube appears elongated to form a long hallway. The same effect can be obtained by observing the figure through an optical device which magnifies the figure twofold. The principle underlying this phenomenon has been described by Bartley[4] and is illustrated in Figure 8. The points A, D and E lie in the picture

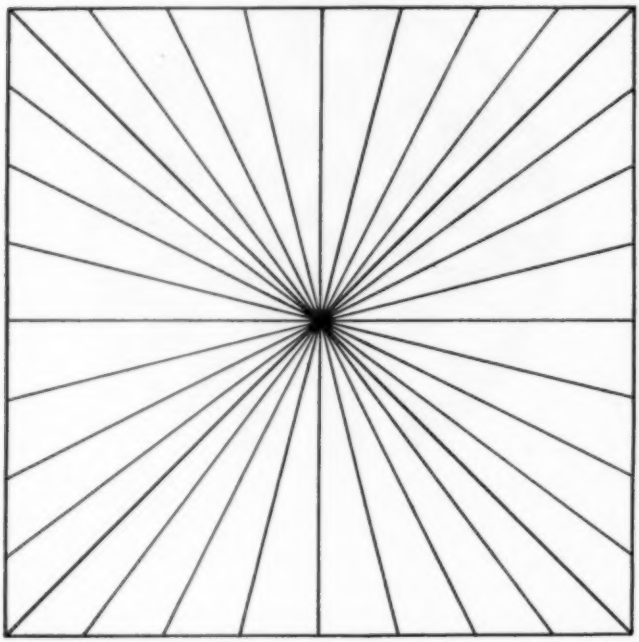

Fig. 6. Figure for demonstrating the role played by the convergence of lines at a vanishing point.

plane. The point A represents the bottom line of the largest square and D represents the bottom line of the smallest square. If the image of A is perceived as lying at A, and if the picture is observed from the point R_1, and if the bottom lines of the squares are perceived as lying in a horizontal plane, the image of D will appear to lie at the point D'_1. However, if the picture is observed from a greater distance, say from the point R_2, the image of D will be perceived at D'_2 which is at a greater distance from A than D'_1 and on this account, the cube is apt to be perceived as elongated into a long hallway.

The principle of elongation in the fore and aft direction by changing the distance of observation is illustrated also in the case of Figure 9, which if observed at a distance of 15 cm. appears composed of squares but if observed at a distance of 30 cm. appears composed of diamond shaped figures. The underlying principles are illustrated in Figure 10

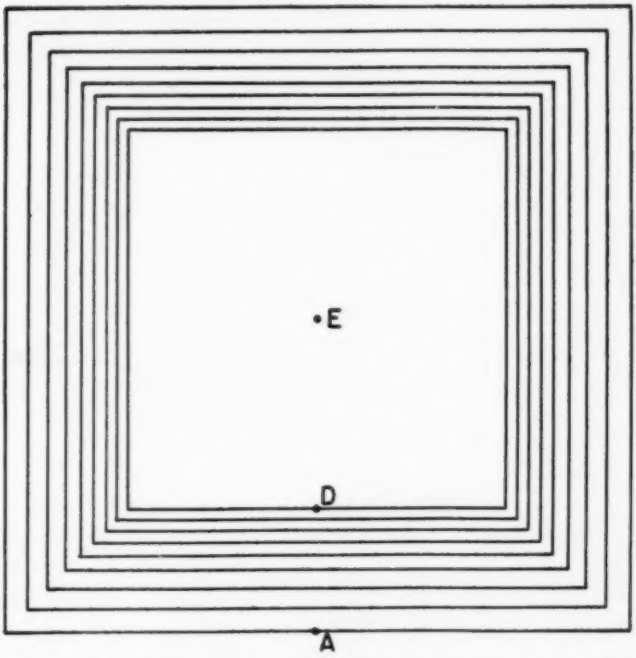

Fig. 7. Figure for demonstrating the role played by the spacing of lines parallel to the picture plane. This figure when viewed from a distance of 15 cm. at a point on a line normal to the picture plane at E represents a cube.

which shows how identical perspective drawings of a diamond and a square can be achieved by choosing the proper viewing distance.

The alignment of the corners of the squares in Figure 7 on converg-

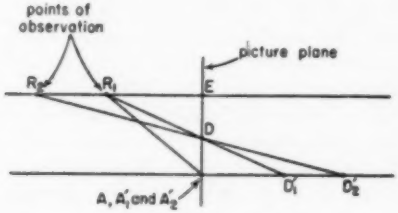

Fig. 8. The effect of changing the point of observation upon the elongation of distances in a fore and aft direction.

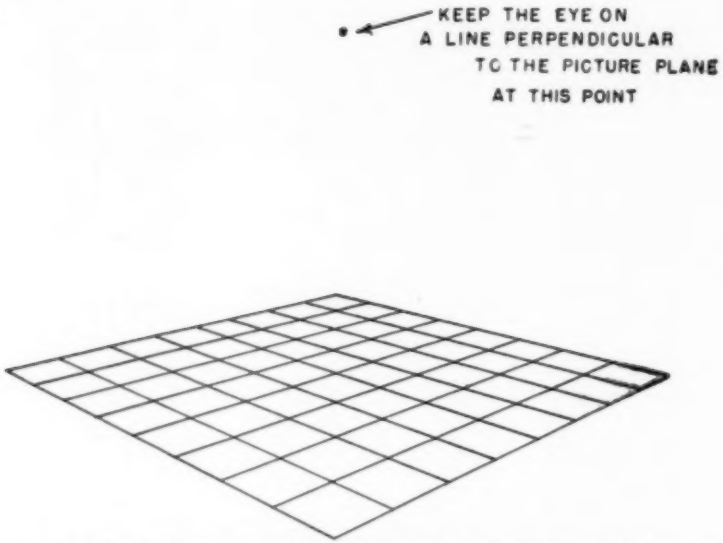

Fig. 9. Figure for demonstrating the effect of distance of observation upon the apparent elongation of a figure in the fore and aft direction. The figure when observed with one eye from a distance of 15 cm. at a point on a line normal to the picture plane at the designated point will appear as a square, but if the distance of observation is increased from 15 cm. to 30 cm., the figure will appear to be elongated in a fore and aft direction and appear like a diamond-shaped figure.

ing lines contributes to the depth effect. A depth effect, however, can be obtained from the spacing of the parallel lines alone as shown in Figure 11, which if viewed from the proper point will give the effect of a space bounded by parallel ceiling and floor but indefinitely extended to the right and left. The two vertical lines in no sense bound the space, but merely the field of view.

In Figure 12, Figure 3 is combined with Figure 7: the combination involves not only the summation of the effect of converging lines and the spacing of lines parallel to the picture plane but included also is the tendency of the observer to perceive the quadrilateral figures as squares, all of which are the same size. When this figure is observed at a distance of 15 cm., at which the figure is a true representation of a cube, the sidewalls, ceiling and floor appear composed of squares.

It is possible to stretch the squares into elongated rectangles by increasing the distance of observation. By the same token, if the distance of observation were reduced from 15 cm. to 7.5 cm., one might expect to squeeze down the size of the rectangular figures in the third dimension, but in this case an even more drastic thing occurs. The figure takes on

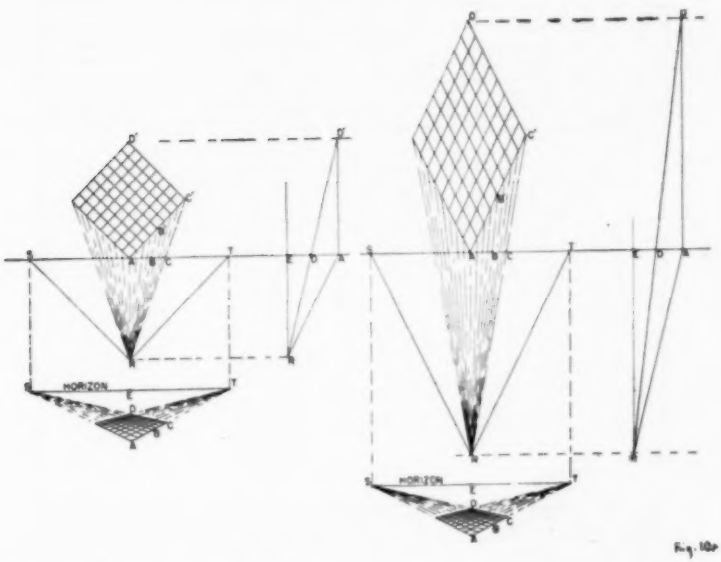

Fig. 10. Method of rendering identical perspective drawings of a square and of a diamond-shaped checkerboard pattern.

the appearance of the inside of a truncated pyramid. When this happens, the lines parallel to the picture plane appear no longer uniformly spaced. This demonstrates at least that the quadrilateral figure HFGK does not necessarily have to be perceived as lying in a horizontal plane. The principle involved is illustrated in Figure 13. A and D instead of being perceived as lying in a plane A′ D′ are perceived as lying in the plane A″ D″. The point A in Fig. 13 is identical with the point in Fig. 12 which lies on the line HK directly below E. The point D in Fig. 13 is identical with the point in Fig. 12 which lies on line FG directly below E.

Another degree of freedom is possible so far as geometrical perspective is concerned. This is illustrated in Figure 14. The points A and D instead of being perceived as lying in the plane A′ D′ may be perceived as lying at a greater distance, namely, in the plane A″ D″. In other words, the floor of the cube in Figure 14, when observed at a distance of 15 cm., may be perceived either as a checkerboard or as large squares of tile such as are used in the floors of buildings.

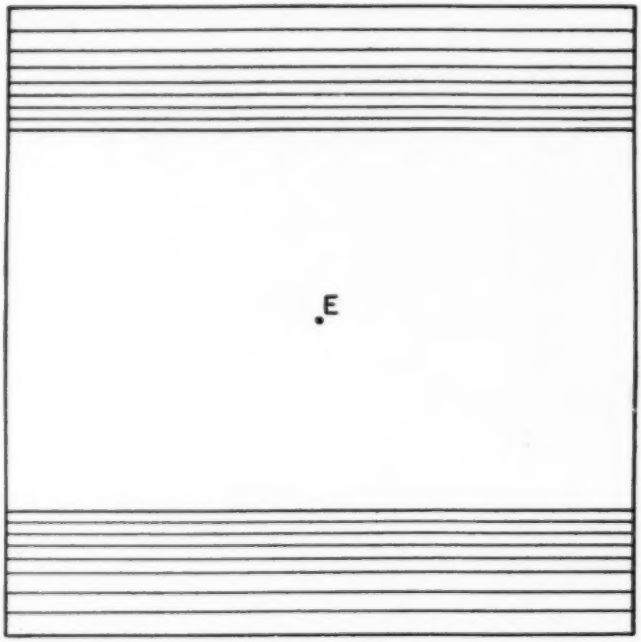

Fig. 11. Figure for demonstrating the effect of the spacing of lines parallel to the picture plane upon the perception of depth.

THE RELATION OF GEOMETRICAL PERSPECTIVE AND STEREO CUES

When a cubical space such as that depicted in Figure 7 is observed binocularly, stereo cues dominate the situation and limit the possibilities. If any one of the squares is seen at the correct distance all the other squares are seen at the correct distance and consequently in this situation where k equals 0 in Equation (3), the cubical space is seen truly as a cube, both in accordance with the geometrical perspective and also in accordance with stereo cues. However, if one of the squares is not perceived at its correct distance, each of the squares must be perceived at a distance given by Equation 3. What this does to the interpretation of geometrical perspective cues is illustrated in Figure 15. A point at infinity on the line MD′ is perceived at E″ at a distance $\rho =$ from the point R, which is 1/k. When all points on the line A′ D′ are seen projected on the line ME″, the perceived distance of any point P′ on the line A′ D′ is given by the following equation, (5) top of page 363,

$$\frac{1}{p} = \frac{1}{x} + k \qquad (5)$$

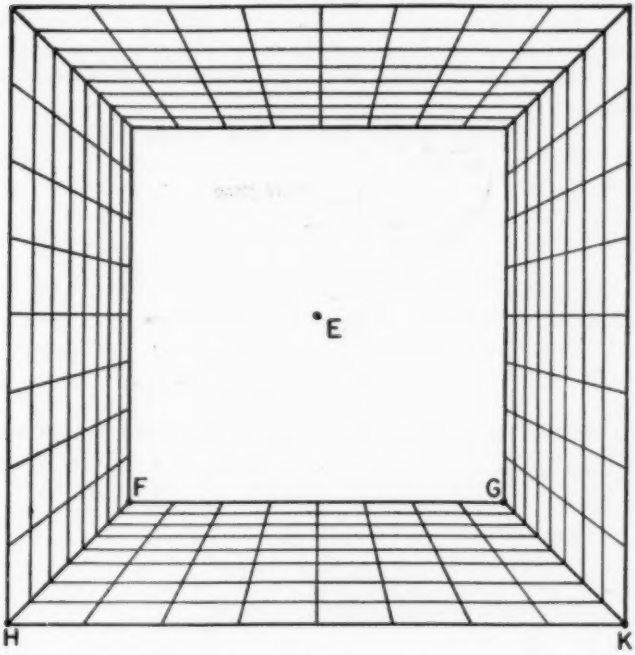

Fig. 12. Figure for illustrating the combined effects of the several factors of geometrical perspective.

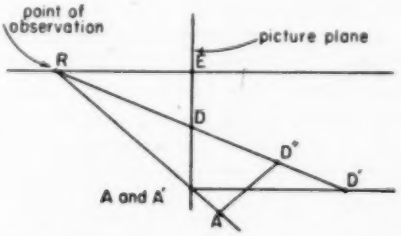

Fig. 13. Principle which makes possible the apparent tilting of the floors, ceiling and walls of a perspective drawing of a cube.

which is identical with Equation (3). This mode of perception which involves the tipping upward of the floor as it recedes into the distance brings the interpretation geometrical of perspective cues into perfect agreement with the interpretation of stereo cues. The common error therefore of judging a horizontal plane such as the ground or floor to slope toward the observer may have its basis in an error of judgment of distance of objects and the dominance of stereo cues over geometrical perspective.

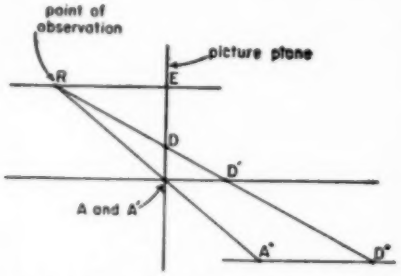

Fig. 14. The basis for perceiving points lying in a horizontal plane at various distances.

The derivation of equation (5) is based on Figure 15 and is as follows:

$$\frac{\sin\ (\beta + \gamma)}{\rho^{\infty}} = \frac{\sin \gamma,}{\overline{RP''}}$$

but for small angles this reduces to

$$\frac{(\beta + \gamma)}{\rho^{\infty}} = \frac{\gamma}{\rho} \qquad (6)$$

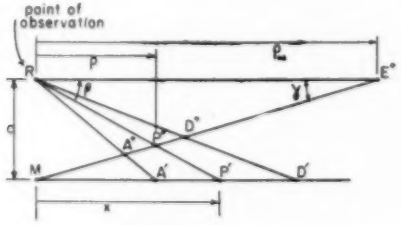

Fig. 15. The relationship between stereo cues and geometrical perspective cues in the perception of depth.

Since $\gamma = \frac{c}{\rho^{\infty}}$ and $\beta = \frac{c}{x}$, and since $\frac{1}{f^{\infty}} = k$, Equation (6) reduces to

$$\frac{1}{\rho} = \frac{1}{x} + k \qquad (5)$$

Helmholtz[2] has described the procedure for constructing a relief model of a three dimensional space, which for binocular vision is equivalent to the original, at least for points lying close to the perpendicular bisector of the base line. The principle is illustrated in Figure 15. The line RE″ is the perpendicular bisector of the base line, R being the midpoint of the base line, and the line MD′ is parallel to RE″. All lines in the original that are parallel to RE″ converge at an arbitrarily chosen point E″ on the line RE″ and points lying on the line MD′ must be located on line ME″ in order to give the proper depth effect.

One can also apply this type of reasoning to the explanation of effects produced by binoculars, stereo range finders and stereographs. Magnification and length of base line are two separate factors that need to be considered. Let us consider the apparent position of two points on the perpendicular bisector of the base line.

If the image of each eye is magnified, this has two effects. In the first place it tends to increase the perceived distance between the two points because it increases the angle subtended by the two points at each of the two eyes. However, the change in angular size of an object causes it to be seen closer to the eyes, and this produces a flattening effect. An increase in the base line increases the perceived distance between the two points. The equation for the perceived distance between the two points in the case of a telescope or a stereo range finder is:

$$(p_1 - p_2) = p_1^2 \; M \; \Phi \; (\gamma_2 - \gamma_1) \; /2 \qquad (7)$$

where M is the angular magnification and Φ is the ratio of the distance between the entrance pupils of the instrument to the subject's interpupillary distance. The same equation applies to a stereograph except that magnification in this case refers to the ratio of the angle subtended by the stereographic image and that subtended by the object at each of the entrance pupils of the stereo-camera, and Φ is the ratio of the distances between the entrance pupils of the camera and the distance between the entrance pupils of the eyes.

MISCELLANEOUS PHENOMENA

The effects obtained with Figures 3, 6, 7, 11 and 12 are helpful in understanding the effects obtained from photographs made with wide angle lenses and telephoto lenses. Figure 16 is a photograph made with a

Fig. 16. Reproduction of a picture from *Life* (p. 137, July 12, 1950). This reproduction would have to be enlarged about 10 times to give correct perspective at a viewing distance of 40 cm. Photograph copyright by *Time, Inc.*, and reproduced with the permission of the copyright owners.

wide angle lens. The "morning-glory" effect is achieved by virtue of the fact that one is apt to observe this photograph at a distance much greater than it ought to be observed. When the photograph is enlarged to a size 10 times the actual size shown and observed at the distance of 40 cm., with the eye on a line perpendicular to the center of the picture, the proper and very striking depth effect is obtained. The photograph illustrated in Figure 17 is actually a small section of a larger photograph

but illustrates the effect which is obtained with a telephoto lens. A photograph made with a telephoto lens is apt to be viewed at a distance shorter than its proper viewing distance. Parallel lines, instead of converging are apt to diverge. The effects obtained with Figures 16 and 17 are further complicated by the fact that in each case the picture plane is not perpendicular to the ground.

The same sort of considerations apply to the field of art. I have examined a large number of Japanese prints from the collection of the Fine Arts Department at the Ohio State University, and almost invari-

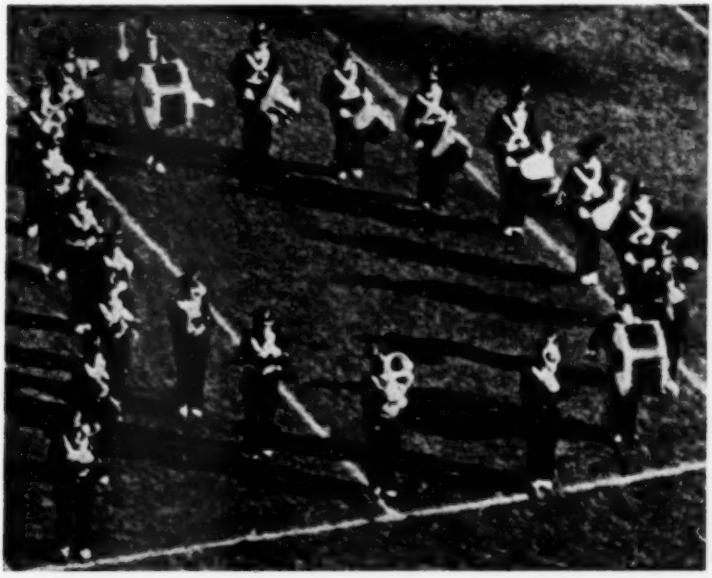

Fig. 17. Reproduction of a small section of a photograph of the O. S. U. Marching Band made by the O. S. U. Photography Department. This reproduction would have to be reduced to 4/15 of its size to give correct perspective at a viewing distance of 40 cm.

ably I find that lines parallel to each other but not parallel to the picture plane are drawn almost parallel to each other. The horizon is at an infinite distance above the top of the picture. Such lines viewed at the ordinary viewing distance give the impression of divergence. This is illustrated by the print shown in Figure 18.

The writer is not familiar enough with the formal training of Japanese artists to draw any conclusions about the method they used

Fig. 18. A print illustrating the perspective characteristics of many Japanese prints. ("A Chinese Dancer" by Maruyama Okyo: Cat. No. 59037 in the O. S. U. Fine Arts Library.)

in constructing their prints, but if anyone knows the answer to this problem, it would be worth reporting. Bunim[7] in reporting on how the problem of perspective has been treated by various artists has pointed out definite trends during definite periods for specific groups of artists. The relation of these anomalies of reproduction in art to anomalies of perception of space, is a fruitful field for further study.

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COMPENDIUM ON EYE PROTECTIVE DEVICES*

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PART I§

INTRODUCTION

The purpose of this manuscript is to familiarize optometrists who contemplate working on occupational visual problems in industry with the major types and styles of industrial goggles and other protective devices, the hazards for which these are designed, and the controls imposed upon industry in matters of eye protection.

The introduction of safety goggles to industry was made very early in this century. The first safety goggles were designed about 40 years ago and their use has spread to practically every type of industry. These first goggles, made in 1909, were crude and inadequate by present day standards. The first lenses were flat, unhardened and the frames were of simple construction. Nevertheless, they performed their function of protection. The outstanding initial success of these goggles furnished an incentive for the ophthalmic manufacturers to engage in experimentation and research to improve the quality of eye protective devices. It was only nine years after the construction of the first goggle that a new process for hardening or toughening glass was announced which increased their impact resistance. These hardened lenses were immediately accepted by industry and are in almost universal use today. Research is still being continued by the optical companies to further improve not only the lenses, but the frame of safety goggles.

Although the first eye protective devices were primarily designed for protection against impact from flying objects alone, many operations, then as now, were greatly in need of protection against other hazards.

(a) *Protection against light hazards.*

In 1910 blue colored glass, known as Pugh glass, was almost

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§Part II will appear in the August, 1952, issue.

universally used in industry for eye protection against heat and glare. Darker shades of glass were used for more intense heat and by open hearth steel men to determine conditions of the melt. There was no appreciation of the absorptive or transmissive values of the glass. As a result, during the next five years a great deal of research was performed on light and spectral analysis and in 1915 a monograph was published entitled, "Scientifially Correct Color Glasses for Industry." This was illustrated with colored plates and tables showing temperature and correct color or combinations of color for protective wear and stressed the dangers of ultra-violet light hazards. From this research, protection against impact was augmented by protection against harmful light and heat radiations in industrial work processes.

(b) *Other Specific Eye Protective Devices.*

Since neither the impact-resistant glass nor the colored glass protected against all types of hazards, such as wind, dust, gases and fumes, studies were continued on the hazards of various tasks. These resulted in specifically designed eye protective devices for specific hazards. These studies have been so successful that it can now be said there is hardly a job in industry for which a specific eye guard has not been designed.

(c) *Corrective-Protective Glasses.*

Due to the fact that many persons in industry who wore conventional corrections for adequate seeing had to be protected also, a protective-corrective combination of lenses was the next logical development. The first step was the use of coverall goggles which fitted over the worker's conventional glasses. The disadvantages of such devices were obvious and, as a result, lenses were developed which incorporated both correction and protection and are known today as corrective-protective lenses.

Most state labor departments, industrial boards, and workmen's compensation commissions have rigid laws, rules, or regulations governing eye protection and the types of goggles or other devices which must be furnished by employers for eye hazardous operations. Insurance requirements are equally exacting and, in addition, safety councils, manufacturers associations, and labor unions have put pressure on industry to establish programs for the prevention of eye injuries.

Most authorities agree that from 95 to 98 per cent of all eye injuries could be prevented by the use of adequate safety programs plus properly designed eye protective devices.

Although tremendous strides have been made in the scientific development of protective devices and in the promotion of their use, a great deal needs to be done along educational lines directed to the

employee, employer, and the professions in the proper dispensing, fitting, adjusting, cleaning, and sterilizing of safety goggles. The profession of optometry can be of considerable assistance to both management and labor by aiding in the above program, and by taking over the complete responsibility for all of the professional services involved when a prescription is incorporated into an eye protective device.

There are two acceptable methods for eye protection commonly practiced in industry. These are:

1. Machine or process guarding.
2. Personal protective equipment.

It is not within the scope of this paper to discuss machine or process guarding. Such procedures and appliances depend upon the specific operation and consequently, if such information is desired, it is suggested that personal observation be made by the interested optometrist of the work process in cooperation with the safety engineer.

Data contained in this report are not original but freely taken from the sources listed in the appendix. It is further conceded that it is not complete, but since the purpose of this paper is to acquaint interested optometrists with basic information, particularly terminology, it should fulfill its purpose.

DEFINITIONS*

1. Protector—A protector is a device which is placed in front of, or over the eyes, face, or head to afford protection from the hazards in industrial processes or from the natural elements.

2. Goggles—Goggles are an optical device worn in front of the eyes, the function of which is protection to the eyes only.

3. Face Mask—A face mask is a device worn before the eyes and over a portion of all of the face, the function of which is protection to the eyes and face.

4. Helmet—A helmet is a rigid device worn by the operator, which shields the eyes, face, neck, and a portion of or all of the other parts of the head, and is held in place by headgear or headband.

5. Hood—A hood is a non-rigid device which completely covers the head, neck, and portions of the shoulders so as to exclude dust and flying particles.

6. Shield—A shield is a device to be held in the hand, or supported without the aid of the operator, the chief function of which is protection to the eyes and face.

*Page 4, Section 12, National Bureau of Standards Handbook, H-24, *American Standard Safety Code for the Protection of Heads, Eyes, and Respiratory Organs.*

CLASSIFICATION

There are three types of goggles commonly in use. These are:

1. Goggles having rigid nonadjustable bridge (or adjustable metallic bridge) without side shields.

2. Goggles having rigid non-adjustable bridge (or adjustable metallic bridge) with side shield. (Figure 1.)

Fig. 1. Goggle. American Optical Company.

3. Goggles having flexibly connected lens containers shaped to conform to the configuration of the face. (Figure 2.)

Fig. 2. Goggle. American Optical Company.

DESCRIPTION OF PROTECTION DEVICES

The descriptions which follow indicate the general classes of protection, and the purpose for which they were designed.

Goggles—Cup Type. Cup type goggles are used to shield the eye and orbit from injury; protection against flying sand, cinders and stone; wood or metal splinters; against particles from grinding or buffing operations; against splashes of acid, caustics, hot liquids and molten metal; and, against sparks and foreign material from welding operations, regardless of the direction or angle from which such hazards come. Equipped with proper filters and shields, they limit the transmission of infra-red and ultra-violet radiation.

Such goggles are designed to fit snugly around the contour of the face and orbits so as to prevent entrance of extraneous particles and

injurious rays. The bridge is flexible to insure proper fitting of both eye cups, and deep cup ("coverall") styles are available for wearing over prescription spectacles. The goggles are held in position with an adjustable head band, and the lenses are impact-resistant.

Cup Type—Clear Impact-Resistant Lenses. (With Perforated Type Side Shields.) This type of goggle, when equipped with clear impact-resistant lenses, is used where the impact hazard is from all angles including the sides: for instance, in chipping, drilling, grinding, quarrying, riveting, scaling and stone dressing: and is suitable for use where spectacle type goggles, with or without perforated side shields, might otherwise be employed.

Cup Type—Clear Impact-Resistant Lenses. (Indirect Vent Type Side Shield.) This type of goggle is used on jobs where a moderate splash hazard (which may or may not be accompanied by the impact hazard) exists: for example, by acid and caustic handlers, galvanizers, picklers and platers: foundry employees, ladle men and pourers: or where there is a moderate dust or wind hazard: for instance, by employees of cement plants, flour mills or grain elevators: by quarrymen and stone dressers.

Cup Type—Impact-Resistant Filter Lenses. Cup type goggles, when equipped with *Light Shade* lenses are used where glare is the principal hazard. They provide the necessary protection from the front, above and below the eye. The side shields provide ventilation and protection from glare (*not* radiant energy) and/or other indirect hazards. They are designed primarily to be worn indoors in places involving a more or less continuous exposure to moderate heat and glare from small masses of molten metal, fire boxes and spot welding (*not* electric welding): by foremen and inspectors (but *not* welders) on medium and light gas welding (oxy-fuel): gas cutting and light electric welding: and, by other employees in nearby areas as protection against extraneous light from such operations. They are of aid to bus drivers, construction workers, linemen, railroad men, shipyard employees, stone dressers, truckers and helpers: or, on other occupations where moderate dust or wind accompany the hazards of glare and impact.

When equipped with *medium* or *dark shades* of lenses, they are used to provide protection from radiant energy, and are adapted for use in medium and light gas welding, gas cutting light electric welding: by foremen and inspectors (but *not* welders) on heavy gas welding, heavy and medium electric arc welding and cutting: by other employees

in nearby areas for protection against extraneous light rays from such operations; and (with added ventilation), can be used in places involving continuous exposure to heat and glare hazards by forgemen, ladle men, heat-treaters, pourers and tappers.

Goggles—Spectacle Type. Spectacle type goggles are similar in appearance to conventional eyewear, and are supported on the nose and held in position by temples. These may be equipped with side shields to provide protection at the sides, but obviously do not provide adequate protection to the eye from particles coming from above or below. They are designed to protect against the frontal impact of chips of metal, wood, stone, sand, cinders, and particles from grinding or buffing operations. This type of goggle affords protection against heat, dust or wind hazards; and, when equipped with light shade filters, against glare.

Spectacle Type—Clear Impact-Resistant Lenses. (Without Side Shields.) This type of goggle is used where the impact hazard is frontal only; for example, by buffers, craters in shipping departments, drill press operators, hand tool users, electrical workers, joiner operators, polishers, shop supervisors, foremen, millwrights, instructors, machinists, and office employees (when going into the shop). Plastic type frame especially adapted for employees in powder plants where non-sparking qualities are desirable.

Spectacle Type—Clear Impact-Resistant Lenses. (With Perforated Side Shields.) This type of goggle is used where the impact hazard is from the side as well as frontal, but not from above or below; for example, by buffers, chippers, circular saw operators, drill press operators, polishers, quarrymen, riveters, scalers, set-up men, shaper operators, stone dressers, crane operators, and other employees engaged near machine operations. When used in places involving continuous exposure to heat (not accompanied by a glare hazard), the portions of the spectacle in contact with the face should be either of low heat conduction material or suitably insulated to prevent face burns or possible infection. Recommended for furnace men and steam-boiler operators.

Spectacle Type—Clear, Impact-Resistant Lenses. (With Unperforated Side Shields.) This type of goggle is used where there is a light dust or wind hazard and/or impact hazard. Transparent, clear side shields permit unobstructed side vision. Recommended for railroad and certain construction workers.

Spectacle Type—Impact-Resistant Filter Lenses. This type of goggle is provided with side shields or without side shields of various

types, for protection against glare (*not* radiant energy), or for one or more of the following purposes: indoors, for gas spot welding (*not* electric welding), foundry and furnace work involving slight exposure to heat; and outdoors, by bus drivers, construction workers, linemen, railroad men, truckers and helpers. Also by electric arc welders, under their helmets for protection against the glare of neighboring operations, and by those working near electric welding operations as protection against stray light rays. When used in places involving exposure to heat, the portion of the spectacle in contact with the face should be insulated to prevent face burns.

Goggles—Miscellaneous. Special purpose goggles are designed to provide a higher degree of eye protection from dust, fumes or other specific hazards than is usually afforded by conventional cup or spectacle type goggles. Generally, the lenses do not meet the high requirements of the "American Standard Safety Code for the Protection of Head, Eyes, and Respiratory Organs," as such goggles are designed primarily for use in situations where a high degree of resistance to impact, glare, etc., is not essential.

Developed as eye protectors for special job situations, they prevent damage to the eye by means of the filtering properties of the lenses and/or by enclosing the eye orbit completely. When provided with impact-resistant lenses, they shield the eyes from the impact of flying particles, and may be used where such hazards exist. The various types are for the following purposes:

Mask Type. (Cloth or Imitation Leather.) Type One, with plain or impact-resistant lenses are designed especially for severe dust and wind hazards. They are used by employees engaged in the manufacture of powdered material, air blowing, car cleaning and light sand blasting; for farm workers (harvesting, threshing and spraying); and for other occupations exposed to fine air-borne particles.

Mask Type. (Rubber or Plastic.) Type Two, with plain or impact-resistant lenses, are designed especially for severe fume, vapor, smoke and liquid splash hazards. They are used by chemists and laboratory employees against fumes, vapors and smoke; by employees handling chemicals, acids and caustics; and in connection with dipping in galvanizing tanks and some japanning processes, and insecticide spraying.

Spectacle Type—Type Three, with cobalt blue lenses, are employed as a protection against glare in steel making; they are commonly used to estimate temperatures and to judge quality and composition of the melt by color changes in the flame.

Face Shields. A face shield consists of a semi-circular sheet of cellulose acetate or other transparent, slow-burning material with a head band. This plastic extends downward to the tip of the nose and posteriorly around the sides of the face to the ears. It is usually far enough away from the face to prevent fogging, and can be worn without interference with corrective spectacles and without reduction in range of vision. Shields are designed primarily for use in situations where a high degree of resistance to impact from large flying objects—is not essential.

They may be used on operations which produce splashes or mild acid or caustics, liquids, hot or cold, which are not solvents for the particular material used in the shields; and machine or hand operations which produce small flying particles, (chips of metal, wood or stone), for grinding or buffing operations, to protect the eyes and face from the impact.

Clear Shields are for use against hazards of impact of small flying particles. These are used in grinding operations, woodworking, metal sawing, buffing, sanding, polishing, plating, removing paint and dirt from ceilings and walls, soldering, chipping operations, pouring operations, (hot liquids, mild acids or caustics), die casting and wire brushing. (Figure 3.)

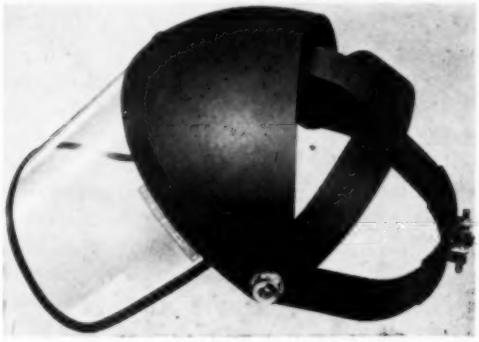

Fig. 3. Clear Shield. American Optical Company.

Colored Shields, (usually a light shade of amber or green), are for use in connection with operations which involve a reflected light or glare hazard which may be accompanied by light flashes or heat or the impact of small flying particles; for instance, spot welding, but *not* electric welding.

Helmets, Hoods and Shields—Welder's Type. The helmet, hood or shield (of vulcanized fiber or other rigid, opaque, non-reflecting, flame and heat resistant material) is equipped with a dark shade of filter glass which limits the transmission of ultra-violet and infra-red to a negligible quantity; the shade of glass selected by each employee (between 8 to 14 inclusive) is that shade which limits the transmission of brightness of the particular welding operation to a degree which enables the employee to see the work clearly, but without the eye receiving radiations which would cause damage. A clear, glass cover plate protects the filter glass against pitting and scratching. Hoods are of flexible material enclosing the head. (Figure 4.)

Fig. 4. Helmet. American Optical Company.

Protection of this type is designed to prevent injury to the eyes and face. These results are accomplished by shielding the eyes, the skin of the face, ears, throat and upper chest, against injurious radiant (heat) energy, spatter of molten metal, sparks and flying particles of scale from welding operations. Helmets, hoods and shields are used primarily for heavy gas welding (oxy-fuel gas) and heavy and medium electric arc welding and cutting. They are made in small, medium and large sizes for men and women. The medium size is designed for use with respiratory equipment when welding or cutting galvanized or painted metal such as brass, zinc or lead. The large size is designed for additional ventilation on heavy or continuous welding operations. When clear vision of the weld for inspection or chipping of scale is desired without removing or tilting the helmet plate holders have the filter lens in a hinged front.

For overhead welding operations helmets may be provided with a front apron to protect the throat. Where welders operate back to back or one above the other, or where women welders are employed, helmets may be provided with a rear apron, or hoods may be used. Where welders are exposed to falling objects, the helmet may be equipped with an impact-resistant hat or cap.*

*Part two, dealing with Specifications and Standards, will appear in the August issue.

ANNOUNCEMENTS

THE SCIENCE OF COLOR

The Optical Society of America announces the publication of the text *"The Science of Color."* This new book is the result of many years' work on the part of the Society's Colorimetry Committee, headed by Dr. Loyd A. Jones, Chairman of the Committee, and assisted by Dr. David L. MacAdam, both men being physicists in the research laboratories of the Eastman Kodak Company.

This book, *"The Science of Color,"* will undoubtedly take its place with the English translation of Helmholtz' *Physiological Optics*, published in 1924. This new work dealing with color is being published for the Optical Society of America by Thomas Y. Crowell, 432 4th Avenue, New York 16, New York. The cost of the book will be $6.50.

STANDARD MARKING FOR FRAMES AND LENS SIZES RECOMMENDED.

According to Mr. Charles F. Oddy, Secretary, Optical Manufacturer's Association, the Technical Committee of the Optical Manufacturer's Association met with members of the Association of Independent Optical Wholesalers and members of the Optical Wholesalers National Association in New York City, June 25. As a result of this meeting, it was recommended that all frames and envelope frame containers be stamped in accordance with the "boxing" method which was approved by the group. Frames will be marked with the actual width of the eye and the distance between lenses. The envelope container will be marked with the actual width of the eye, the height of the eye and the distance between lenses. All frame manufacturers are being urged to follow this uniform program of frame marking.

CHANGES IN CORNEAL ASTIGMATISM*

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References to the development of inverse astigmatism of the cornea as age advances are seen occasionally in ophthalmic literature. Such changes are usually attributed to hardening and shrinkage of the corneal tissue and this explanation is generally accepted, but a recent investigation throws doubt on the matter.

For some years the writer measured corneal astigmatism in nearly every case, recording the results for comparison with other measurements of astigmatism in the same eyes. These records were not used for any other purpose until recently, after the writer had been criticized for not giving consideration to the work of Javal on the subject of changes in corneal curvature.

In the criticism it was stated that at about 50 years of age the cornea tends to change curvature through shrinkage, its anterior surface becoming spherical or less astigmatic if astigmatism with the rule existed in the earlier years.

In order to test the validity of this statement, an analysis of the above mentioned records was made, in ten-yearly age groups from the decade 10-20 to 70-80. Each age group was divided according to the presence of direct-, inverse-, and non-astigmatic anterior corneal surfaces, with the following results:

TABLE SHOWING THE DISTRIBUTION OF CORNEAL CURVATURE

Age Groups				10-20				20-30				30-40			
I Inverse	S Spherical			I	S	D	T	I	S	D	T	I	S	D	T
D Direct	T Total			11	29	124	164	22	52	194	268	36	37	131	204
Percentages				6.8	17.7	75.5	100	8.2	19.5	72.3	100	17.7	18.2	64.1	100

40-50				50-60				60-70				70-80			
I	S	D	T	I	S	D	T	I	S	D	T	I	S	D	T
82	88	150	320	113	99	144	356	81	68	90	239	49	39	52	140
25.6	27.5	46.9	100	31.7	27.8	40.5	100	33.9	28.4	37.7	100	35	27.8	37.2	100

On consulting the table made from these results, it will be seen that, throughout the whole of the period under review, the incidence of direct astigmatism of the cornea becomes smaller while that of inverse astigmatism becomes greater, sphericity remaining at a steady level be-

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fore 30 years of age and at a higher steady level after 50 years of age, the only change in the incidence of sphericity being the sharp rise between 30 and 50. It is important to note that during this 30 - 50 age group, the decrease in the incidence of direct astigmatism is more than twice as marked as in any other decade. The proportion of corneal with inverse astigmatism shows a steady increase between the ages of 24 and 55, rising from 8 per cent to 32 per cent, after which it rises only another 3 per cent in the remaining 20 years.

A significant fact is that, between 65 and 75 years of age, there is no change worth mentioning in the shape of the anterior corneal surface. Is this because tissue hardening and shrinkage stops at 65 years of age? Judging by the faces of elderly people, this is not so. Or is it because accommodation is almost negligible at that age? Remember that the table shows the greater changes in corneal curvature occurring in the period 30 - 50, when accommodation is under greater strain owing to uncorrected hypermetropia and presbyopia.

It is submitted that this analysis shows that the development of inverse astigmatism of the cornea has much more connection with depletion of accommodation than with hardening and shrinkage of the corneal tissue. How this connection can be effected is a subject for speculation, and although this is not a place for the introduction of contentious theories, I would point out that the act of accommodation is accompanied by the act of convergence and that, during this act, the medial recti may have a distorting effect on the surface of the globe.

The main reason for this paper is to stimulate interest among American observers and endeavor to obtain analyses of their records of corneal curvature. The use of the keratometer is much more general in America than in England, and my information is that American methods place the emphasis on actual curvatures. My records are in the form of correcting cylinders, and do not indicate whether the inverse astigmatism is due to increasing curvature of the horizontal meridian or flattening of the vertical meridian of the cornea.

It may be that keratometer results obtained in America will be different from those obtained in England. The greater use of spectacles, especially between the ages of 30 to 50 and the wearing of trifocals may affect the issue, as may greater extremes of climate. If American optometrists would analyze their records on my lines, however, I think the results would show broad agreement with mine and open up a useful field of inquiry.

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CONFERENCE OF PUBLISHERS AND OPTOMETRISTS NEEDED

At the time this is written, the new optometry Bill S 106, for the District of Columbia, is being held up in committee largely because of the opposition of a certain small group of congressmen led by representative Harold Hagen (R) of Minnesota. The bill has passed the Senate. Before this reaches our readers, the committee will have approved the measure as it is, or will have amended the act, or possibly, will have entirely killed it, or let it die in committee.

Naturally we Minnesota optometrists are all somewhat embarrassed at this sort of goings-on. We expect the fullest support on the part of our elected officials, and Congressman Hagen's position in this matter will make him notorious in optometric circles for some time to come.

While the matter is as yet undecided—and the fate of the Bill

is unknown—it is still a matter which is fresh in our minds, and perhaps it is well to analyze, if we can, just what has happened. Perhaps there is some explanation for Congressman Hagen's position, although certainly it will not be one which will please us or optometry in general.

Why have we run into this opposition? Especially from this unexpected source. Congressman Hagen has a rural district. A census of living things up there would probably show more black bears and deer than voters residing in the northwest corner of Minnesota. There are no large cities in this area, and the few optometrists who practice in his district, do so for the greater part in conformity with the code of practice of the A. O. A.

Congressman Hagen numbers among his constituents very few commercial optometrists. Why then this opposition? It is misleading to believe that unorganized commercial optometry in some way "got to him." By his past reputation, we know him to be, *not* that kind of a man. What then did happen?

The facts of the matter are that the publishers' associations are strongly opposed to any and all restrictions on, or of, advertising. Congressman Hagen is an ex-newspaper man. He is probably an association man. He is obviously following his own associations' dictates when he opposes our Bill which limits price advertising on the part of optometrists in the District of Columbia.

We, as optometrists, do not see eye-to-eye with the publishers at this point. We feel the commercial optometrist, through his price advertising, is improperly presenting his type of service to the public, and that newspapers in accepting this copy, and in fighting to continue this type of practice, are assisting an activity that frequently does an injustice to the public.

We have discussed this point with a Minneapolis publisher who claims that if the matter only revolved around "optical copy" then there would probably be no opposition. He pointed out, however, that a certain religious group would like to prohibit all drug and therapeutic health advertising, and that the "drys" would like to prohibit all beer and liquor advertising. He pointed out, too, that other groups would like to regulate or abolish other forms of advertising, and as publishers they must resist any and all efforts in this direction as when adopted these individual legislative programs set precedents for other more all-embracive controls. This is the point around which the conflict centers, he believes, and is the point Congressman Hagen is trying to make.

In optometry some states already prohibit price advertising on the

part of optometrists, as this has long been considered by us as "bait" or misleading copy. Many former price advertisers rarely sold materials at the price quoted in the ad.

In time all states will have this provision in their acts regulating optometry in the public's best interest. The congress will adopt such a law for the District of Columbia—if not this year—probably next. Optometry will continue to work on this problem until the activity is eradicated in spite of the opposition from remaining commercial optometrists, and from the publishers.

There is little we can do with the commercial optometrist. He has been talked to, and reasoned with—but he is adamant. He will advertise—and he will do it with price advertising if permitted.

Irrespective of whether we can, or cannot, overcome the present opposition in Washington, and we hope we can, perhaps the time is ripe for our A. O. A. leaders to arrange a conference with the national leaders in the publishing field. A careful presentation of optometry's views might be of value in getting their legislative spokesman to be less vocal on this point in the future. With more and more legislative fights of this kind ahead, it certainly is worth a try.

CAREL C. KOCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

ACADEMY LUNCHEON AT A. O. A. CONGRESS

A highly successful meeting of Academy Fellows was held at Miami Beach in June in conjunction with the A. O. A. annual Congress. A total of 70 guests attended and heard brief talks by Dr. H. C. Bumpous, secretary of the Florida chapter, Dr. Lawrence Fitch of Pennsylvania State College of Optometry, Dr. Ernest Kiekenapp, A. O. A. secretary, Dr. Richard Feinberg, Dean, Northern Illinois College of Optometry, and A. O. A. President J. Ottis White.

LOCAL CHAPTER ACTIVITIES

NEW YORK ACADEMY

A research paper prepared by four members of the graduating class of the School of Optometry, Columbia University, was heard by Fellows attending the June meeting of the New York Academy. The paper was chosen by the College faculty as the best of those written

by members of the class. The title of the paper was "Accommodative Levels Under Conditions of Asymmetric Convergence," and prepared jointly by Lawrence Abelman, Bernard Brodsky, Nathan Flax and Robert Rosenberg.

FLORIDA CHAPTER

Elections were held at the semi-annual meeting of the Florida Chapter in June with Dr. James F. Loomis of Jacksonville being chosen president. Other officers elected are Dr. Karl K. Eychaner, Tampa, vice president, and Dr. H. C. Bumpous, St. Petersburg, re-elected secretary-treasurer. Members of the executive committee, in addition to officers, are Dr. Marshall Wright, Live Oak, and Dr. S. B. Schumacher, Jacksonville. The Florida Chapter sponsored the Academy luncheon held at the A. O. A. Congress.

SAN FRANCISCO BAY AREA CHAPTER

Newly-elected chairman of the San Francisco Bay Area chapter is Dr. Kenneth Stoddard, Berkeley; vice chairman, Dr. Gordon Walls, Berkeley; secretary-treasurer, Dr. E. Jean Babbitt. Member of the executive council—Dr. Arthur Jampolsky, and chairman of the committee on admissions, Dr. Arthur B. Emmes. The election took place at the May 29th meeting, at which Dr. Henry Peters gave a report on papers presented at the A. O. A. Seminar on Occupational Vision held in March in Chicago, and Dr. Stoddard reported on the General Electric Lighting Institute Symposium in April in Cleveland.

SOUTHERN CALIFORNIA CHAPTER

Two Fellows of the Southern California chapter spoke at the June meeting. Dr. Donald R. E. Waters talked on "Hyperphorias in Facial Asymmetry," and Dr. Henry W. Hofstetter on "Case Record Design."

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

A. O. A. CONVENTION REPORT

JAMES F. WAHL ELECTED PRESIDENT

Dr. James F. Wahl, Anna, Illinois, was elected president of the American Optometric Association at its annual Congress in Miami Beach.

Florida, June 8-11, 1952. Dr. Wahl has been serving as a vice president. He is a Fellow of the American Academy of Optometry.

Outgoing president Dr. J. Ottis White, Baton Rouge, Louisiana, was elected a trustee, and other officers elected at Miami Beach are as follows: Dr. Sam L. Brown, Fostoria, Ohio, first vice president; Dr. Norman B. Hays, Niagara Falls, New York, second vice president; Dr. Joseph M. Babcock, Portsmouth, Ohio, re-elected third vice president; Dr. Rupert E. Flower, Visalia, California, fourth vice president (new on the board); Dr. Leo A. Miller, Lincoln, Nebraska, treasurer, and for the 31st consecutive year, Dr. Ernest Kiekenapp, Minneapolis, Minnesota, was re-elected A. O. A. secretary.

Also a new staff post was created by the A. O. A. during the Congress. This staff position is Managing Director of the A. O. A. Mr. J. Harold Bailey, Montebello, California, was engaged in this capacity and he will assist the officers and trustees with administrative and detail work. The report is that he will headquarter in Chicago.

Annual reports were presented to A. O. A. delegates at the Congress as follows: President's report, Dr. J. Ottis White. Secretary's report, Dr. Ernest H. Kiekenapp. On national affairs, Mr. William P. MacCracken. On military problems, Commander R. R. Sullivan. On contact lenses, Dr. Ward Ewalt, Jr., and Dr. E. F. Richardson. On visual acuity charts, Dr. Carl Shepard. On school children's vision, Dr. Lois Bing. On legal problems of optometry, Mr. Harold Cohn, A. O. A. legal counselor. On occupational vision, Dr. Elmer Westland, and on public relations, Dr. Elmer Soles.

Nearly 950 were present at the Congress. One of the highlights of the Miami convention was a banquet given by Mr. Vincent Salierno, president of Victory Optical Company. All registrants attended.

Rochester, New York, was chosen the 1953 Congress city, with June the scheduled month.

CAMPUS NEWS

HENRY HOFSTETTER NAMED INDIANA DIRECTOR

Dr. Henry W. Hofstetter, now dean of Los Angeles College of Optometry, and a leader in optometric educational affairs since entering the teaching field in 1939, has been named director of the new division of optometry at Indiana University. The announcement was made by Dr. H. T. Briscoe, dean of the faculties at Indiana University.

The appointment is a well deserved one for Dr. Hofstetter who has been active during his entire career in furthering the progress of optometry—on committees, in research work and as a major contributor to the optometric literature.

Ohio-born Dr. Hofstetter attended Western Reserve, Kent State and the Ohio State universities, receiving from the latter three degrees—B.Sc. in optometry, M.Sc. and Ph.D. in physiological optics. From 1939-1948 he served on the faculty of the optometry school at Ohio State. He is a Fellow of the American Academy of Optometry, on the Editorial Council of the *American Journal of Optometry*, chairman of the educational policy committee of the Association of Schools and Colleges of Optometry, and a member of the recently-created National Board of Examiners in Optometry. He will assume his new duties, which include setting up the optometry curriculum and supervising pre-optometry students, on August 1, 1952. The new optometry division was created by an act of the Indiana State Legislature in 1951.

ANNUAL TRUSTEES MEETING CHICAGO COLLEGE

Morton L. Abram, Ll. B., D.O.S., of Glencoe, Illinois, was elected president of Chicago College of Optometry at the annual meeting of the Board of Trustees on June 25. For nearly a year he has served in the capacity of acting president.

Reviewing plans for the 1952-'53 academic year the Board noted with approval that the Fall 1952 registration will exceed that of last year.

Eugene Freeman, O.D., D.O.S., Ph.D., continues as dean of the college.

Samuel D. Hauser, O.D., of Chicago, was elected chairman of the Board of Trustees. Sidney Levinson, M.D., of Chicago, director of the Michael Reese Foundation, was elected chairman of the board's executive committee.

Samuel D. Hauser, O.D., Chicago; Carel C. Koch, O.D., D.O.S., Minneapolis, and Henry Wolff, O.D., D.O.S., Marshalltown, Iowa, were elected to three-year terms on the Board of Trustees. Louis Falk, O.D., Chicago, and Oscar Weinstein, O.D., Rockford, Illinois, were elected for two-year terms. Sidney Levinson, M.D., and William Weinress, both of Chicago, were elected for one-year terms.

GRADUATIONS

Graduation news from across the country: Massachusetts College of Optometry graduated 77 students June 6, with 13 receiving Bachelor of Science, major in optometry degrees and the others certificates of graduation. Dr. Walter I. Brown was the principal speaker, and also was awarded the honorary degree of Doctor of Ocular Science, the first to be awarded by Massachusetts College.

At Southern College of Optometry commencement exercises in

June, 44 were awarded Doctor of Optometry degrees. Dr. Joseph S. Stabnick, M.D., gave the commencement address.

On May 25, Pacific University awarded 46 Bachelor of Science, major in optometry degrees, and 44 Doctor of Optometry degrees at spring commencement. Dr. Seabury C. Mastik was the commencement speaker; P. U. President Walter C. Giersbach presided over the exercises.

The first class to finish the five year curriculum at Chicago College of Optometry was graduated June 20, with Dr. Ernest Hutchinson, president, Los Angeles College of Optometry, the commencement speaker. Twenty-six students were graduated, receiving the Doctor of Optometry degree. At the exercises, the honorary degree of Doctor of Ocular Science was conferred on Dr. Hutchinson, Dr. Herbert P. McDonald, Sr., of Mobile, Alabama, and Dr. Frank C. Wilson, secretary of the Georgia Optometric Association, who began his practice in 1916. Dr. McDonald and Dr. Wilson each had a son graduating from C. C. O. in 1952.

Dr. Carel C. Koch, Editor, *American Journal of Optometry*, was the commencement speaker at Pennsylvania State College of Optometry, which graduated 132 at spring commencement in Philadelphia, June 2. Dr. Albert Fitch, President of the College, presided. Approximately 2,000 persons attended the exercises which were held in the Town Hall auditorium. All graduates received the Doctor of Optometry degree.

SUMMER WORKSHOPS

Summer workshops in occupational vision and optometry held this month at Northern Illinois College of Optometry. Dr. Richard Feinberg, Dean, directed the workshop in occupational vision July 14-23. The main speaker was Mr. R. J. Diefenthaler, district engineer, Lamp Division, General Electric Company. Other speakers were Dr. Elmer H. Westland, chairman, A. O. A. Occupational Vision Committee; Mr. R. A. Sherman, director, Department of Occupational Vision, Bausch and Lomb Optical Company; Dr. Frederick Kushner, chairman, I. O. A. Occupational Vision Committee; Dr. Carl Shepard, Director of Research, N. I. C. O., and Mr. William Cameron, director, Department of Occupational Vision, American Optical Company.

Speakers at the optometry workshop held July 19-23 at N. I. C. O. were Dr. Peter C. Kronfeld, ophthalmologist, who spoke on "Early Glaucomatous Excavation;" Dr. Albert Biegel, on "New Developments in Ocular Surgery;" and Dr. Maurice D. Pearlman, "New Developments in Medical Treatment of Eye Disease."

DONATION TO PACIFIC UNIVERSITY

A prominent San Francisco optometrist has donated to Pacific

University his prepared lecture material gathered over a period of 30 years. The gift from Dr. T. A. Brombach includes 200 colored projection slides covering the results of his original investigation of motion, form and color fields in endogenous and exogenous toxemias, brain lesions, functional blind spots, and fatigue; and also original data from a factory survey in which the fatigue factor and relationship of peripheral fields to accident proneness was investigated. This material will be made available to students through classwork and practitioners of the area through seminars.

OHIO STATE NEWSLETTER

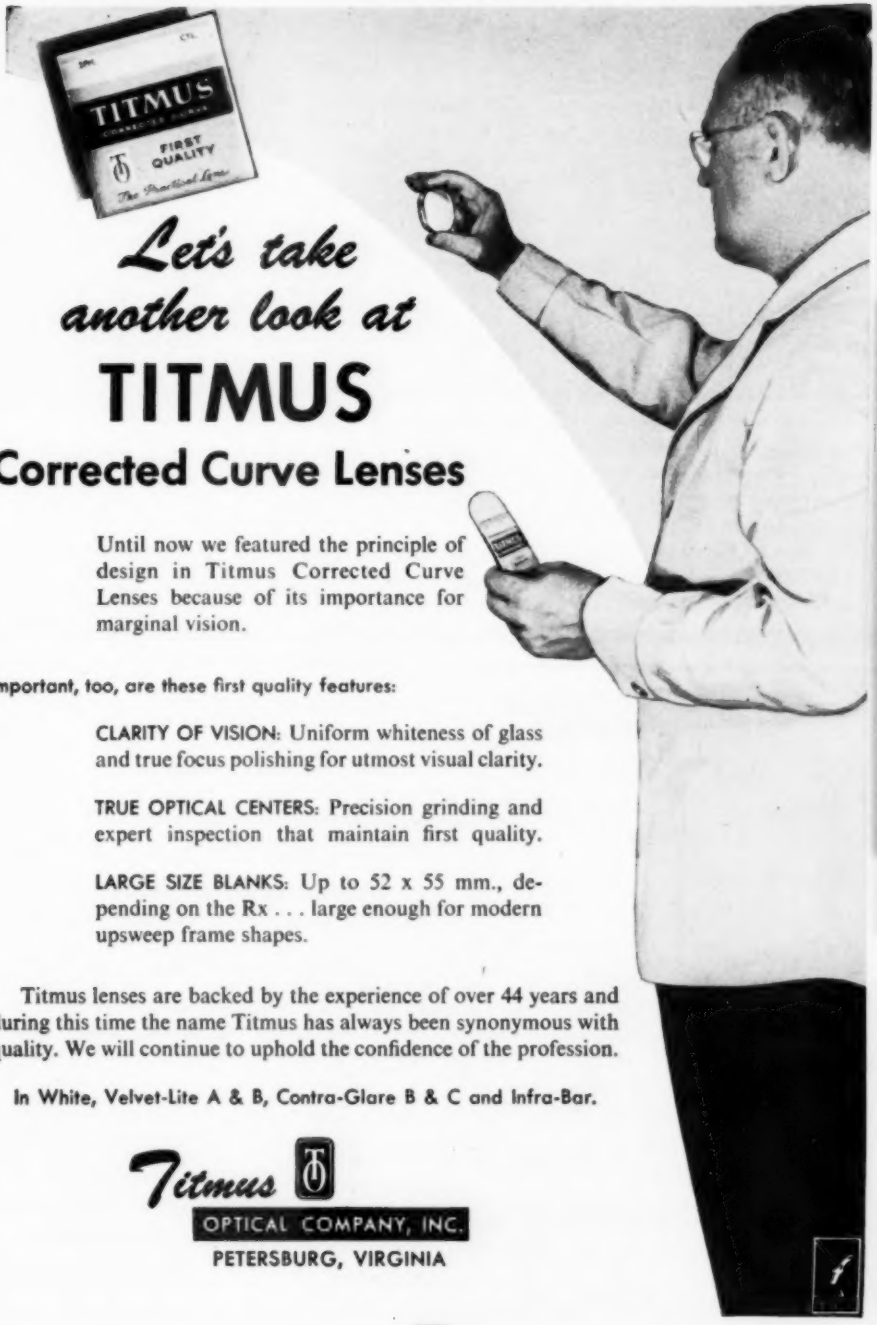
Through a new booklet, "1952 Newsletter of The Ohio State University School of Optometry," it is now possible, in a few minutes reading time, to get a complete picture of the school's facilities, activities, curriculum, research program and progress during past years. The bulletin was prepared partially as a general information newsletter, but specifically to give the school's alumni a comprehensive, up-to-date review of their alma mater. A listing of the material covered will show the care with which this very informational newsletter was prepared: Letter addressed to alumni from Dr. Glenn Fry, Director. Explanations of the undergraduate, graduate and postgraduate programs, research activities, news of student organizations, staff activities, background of faculty, and graduate student activities, scholarships available, clinic work, and descriptions of the Lionel Topaz Memorial Library and school museum. Dr. Vincent Ellerbrock supervised the preparation of this material.

The school is to be complimented on the preparation of this newsletter, and we're sure the work which has gone into it will be appreciated not only by the alumni, but by the optometric press and others who constantly need background material on optometric affairs.

GOOD PUBLICITY

We're wondering if Dr. L. F. Crowell of Hillsboro, Oregon, has a daughter by the name of Susan. The *Saturday Evening Post* has a fiction piece about a Dr. Susan Crowell, a lady optometrist and Chamber of Commerce president of "Oceancrest, Oregon." Steve McNeil wrote the story, and it's o.k.

And while we're on the subject of stories, have you read the *Life* article on the new proposed visual acuity charts first presented at Miami Beach by Dr. Carl Shepard, director of research at N. I. C. O.?



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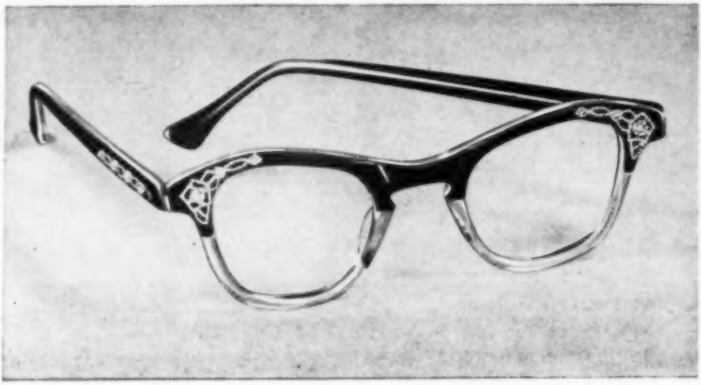

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